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THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

1913

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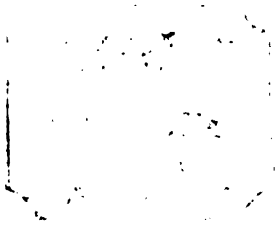

PRESIDENT 1913

TRANSACTIONS

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

VOLUME IX

Third Western Meeting, Chicago, Ill., September 18, 1913

Ninth Annual Meeting, New York, N. Y., December 1 and 2, 1913

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SCHOOL OF ENGINEERING
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Incorporated under the Laws of the State of New York
August 30, 1905.

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OFFICERS
OF
THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

1912-1913

PRESIDENT

PETER NEFF.....Canton, Ohio

VICE-PRESIDENTS

HENRY TORRANCE, JR.....New York, N. Y.
(*Term expires at Annual Meeting of 1913*)

THEODORE KOLISCHER.....Philadelphia, Pa.
(*Term expires at Annual Meeting of 1914*)

DIRECTORS

LOUIS BLOCK.....New York, N. Y.
LOUIS DOELLING.....New York, N. Y.
EDWARD N. FRIEDMANN.....New York, N. Y.
HENRY VOGT.....Louisville, Ky.
CONRAD H. YOUNG.....Pittsburgh, Pa.
(*Terms expire at Annual Meeting of 1913*)

CHARLES L CASE.....Boston, Mass.
THEODORE O. VILTER.....Milwaukee, Wis.
HEYWOOD COCHRAN.....Chicago, Ill.
L. C. NORDMEYER.....St. Louis, Mo.
JUNIUS H. STONE.....New York, N. Y.
(*Terms expire at Annual Meeting of 1914*)

P. DE C. BALL.....St. Louis, Mo.
CARL BEHN.....New York, N. Y.
EZRA FRICK.....Waynesboro, Pa.
JOHN LEVEY.....Chicago, Ill.
THOMAS SHIPLEY.....York, Pa.
(*Terms expire at Annual Meeting of 1915*)

TREASURER

FRANK A. HORNE.....New York, N. Y.

SECRETARY

WILLIAM H. ROSS.....New York, N. Y.

PAST AND PRESENT OFFICERS

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JOHN E. STARR—1905 ..... New York, N. Y.
W. EVERETT PARSONS—1906 ..... Newark, N. J.
D. S. JACOBUS—1907 ..... New York, N. Y.
EDGAR PENNEY[1]—1908 ..... Newburgh, N. Y.
LOUIS BLOCK—1909 ..... New York, N. Y.
RODERICK H. TAIT—1910 ..... St. Louis, Mo.
EDWARD N. FRIEDMANN—1911 ..... New York, N. Y.
THOMAS SHIPLEY—1912 ..... York, Pa.
PETER NEFF—1913 ..... Canton, Ohio

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P. DE C. BALL—1905-1906 ..... St. Louis, Mo.
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HOMER MCDANIEL—1909-1910 ..... Cleveland, Ohio
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ALBERT RUEMMELI—1911-1912 ..... St. Louis, Mo.
HENRY TORRANCE, JR.—1912-1913 ..... New York, N. Y.
THEODORE KOLISCHER—1913-1914 ..... Philadelphia, Pa.

TREASURERS

WALTER C. REID—1905-1911 ..... New York, N. Y.
FRANK A. HORNE—1912-1913 ..... New York, N. Y.

SECRETARY

WILLIAM H. ROSS—1905-1913 ..... New York, N. Y.

DIRECTORS

LOUIS BLOCK—1905-1908 and 1911-1913 ..... New York, N. Y.
W. EVERETT PARSONS—1905 ..... Newark, N. J.
EDGAR PENNEY[1]—1905-1907 ..... Newburgh, N. Y.
D. S. JACOBUS—1905-1906 ..... New York, N. Y.
E. L. PHILLIPS—1905-1906 ..... New York, N. Y.
W. T. ROBINSON—1905-1906 ..... Philadelphia, Pa.
L. HOWARD JENKS—1905-1907 ..... New York, N. Y.
THOMAS SHIPLEY—1905-1911 and 1913-1915 ..... York, Pa.
HENRY TORRANCE, JR.—1905-1907 ..... New York, N. Y.
H. B. ROELKER—1906-1908 ..... New York, N. Y.
J. J. DE KINDER—1907-1909 ..... Philadelphia, Pa.
F. W. PILSBRY—1907-1909 ..... Chicago, Ill.

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1 Deceased.

DIRECTORS—Continued

LLEWELLYN WILLIAMS—1907-1909.....Boston, Mass.
JOHN E. STARR[2]—1908.....New York, N. Y.
JOHN C. WAIT—1908-1910.....New York, N. Y.
KARL WEGEMANN—1908-1910.....New York, N. Y.
MADISON COOPER—1909-1911.....Watertown, N. Y.
N. H. HILLER—1909-1911.....Carbondale, Pa.
W. H. MANNS—1909-1911.....Waynesboro, Pa.
CHARLES DICKERMAN—1910-1912.....Philadelphia, Pa.
EDWARD N. FRIEDMANN[3]—1910 and 1912-1913.....New York, N. Y.
GARDNER T. VOORHEES—1910-1912.....New York, N. Y.
CARL BEHN[4]—1911-1915.....New York, N. Y.
LOUIS DOELLING—1911-1913.....New York, N. Y.
VICTOR H. BECKER[5]—1912.....Chicago, Ill.
CHARLES L. CASE—1912-1914.....Boston, Mass.
THEODORE O. VILTER—1912-1913.....Milwaukee, Wis.
HENRY VOGT—1913.....Louisville, Ky.
CONRAD H. YOUNG—1913.....Pittsburgh, Pa.
JUNIUS H. STONE—1913-1914.....New York, N. Y.
HEYWOOD COCHRAN[6]—1913-1914.....Chicago, Ill.
L. C. NORDMEYER—1913-1914.....St. Louis, Mo.
P. DE C. BALL—1913-1915.....St. Louis, Mo.
EZRA FRICK—1913-1915.....Waynesboro, Pa.
JOHN LEVEY—1913-1915.....Chicago, Ill.

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2 Filled the unexpired term, 1908, of Edgar Penney.
3 Filled the unexpired term, 1912-1913, of Thomas Shipley.
4 Filled the unexpired term, 1911-1912, of Edward N. Friedmann.
5 Deceased.
6 Filled the unexpired term, 1913-1914, of Victor H. Becker, deceased.

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

CONSTITUTION

NAME, OBJECT AND GOVERNMENT

C 1. The title of this Society shall be "The American Society of Refrigerating Engineers."

C 2. The object of this Society is to promote the Arts and Sciences connected with Refrigerating Engineering.

C 3. The principal means for this purpose shall be the holding of meetings for the reading and discussion of appropriate papers, and for social intercourse; the publication and distribution of its papers and discussions; and the maintenance of a library of data on refrigeration.

C 4. The society shall be governed by this Constitution, and by By-Laws and Rules in harmony therewith.

C 5. The Society shall be organized as a Corporation under the Laws of the State of New York.

MEMBERSHIP

C 6. Persons connected with the Arts and Sciences relating to Refrigerating Engineering may be eligible for admission into the Society.

C 7. The membership of the Society shall consist of Members, Associates and Juniors. Members and Associates are entitled to vote and to hold office. Juniors shall not be entitled to vote nor to be officers of the Society, but shall be entitled to the other privileges of membership.

C 8. Members and Associates are entitled to vote on all questions before any meeting of the Society, in person or by proxy, given to a voting member in writing. A proxy shall not be valid for a greater time than six months.

C 9. A member shall be twenty-six years of age or over. He must have been so connected with Refrigerating Enginering as to be competent as a designer or as a constructor, to take responsible charge of work in his branch of Refrigerating Engineering, or he must have served as a teacher of Refrigerating Engineering for more than five years.

C 10. An Associate shall be twenty-six years of age or over and shall be so connected with Refrigerating Engineering as to be competent to take charge of engineering work, or to co-operate with Refrigerating Engineers.

C 11. A Junior shall be twenty-one years of age or over. He must have had such Refrigerating Engineering experience as will enable him to fill a responsible subordinate position in Refrigerating Engineering work, or he must be a graduate of an engineering school.

C 12. The rights and privileges of every Member, Associate and Junior shall be personal to himself, and shall not be transfer able or transmissible by his own act or by operation of law.

ADMISSION

C 13. All applications for membership as Member, Associate or Junior shall be presented to the Council, which shall consider and act upon each application, assigning each approved applicant to the classification to which, in the judgment of the Council, he is entitled. The name of each candidate thus approved by the Council, shall, unless objection is made by the applicant, be submitted to the voting membership for election by means of a letter ballot.

C 14. Associates or Juniors desiring to change their grade of membership shall make application to the Council in the same manner as is required in the case of a new applicant.

C 15. Election to membership shall be by a sealed letter ballot as the By-Laws shall provide. Adverse votes to the number of four per cent. of the votes cast shall be required to defeat the election of an applicant.

C 16. Each person elected shall subscribe to this Constitution, and shall pay the initiation fee before he can be entitled to the rights and privileges of membership. If such person does not comply with these requirements within six months after notice of his election, he will be deemed to have declined election. The Council may, thereupon, declare this election void.

INITIATION FEES AND DUES

C 17. The initiation fee for membership shall be as follows:
For Members and Associates, five dollars.
For Juniors, five dollars.

A Junior on promotion to any other grade of membership shall pay an additional fee of five dollars.

The annual dues for membership shall be as follows:

For Members and Associates, fifteen dollars.

For Juniors, ten dollars, for the first six years of their membership, and thereafter the same as for a Member or Associate.

SUSPENSIONS AND EXPULSIONS

C 18. Any Member, Associate or Junior who shall leave his annual dues unpaid for two years shall, at the discretion of the Council, have his name stricken from the roll of membership and shall cease to have any further rights of membership.

C 19. The Council may refuse to receive the dues of any Member, Associate or Junior who shall have been adjudged by the Council to have violated the Constitution or By-Laws of the Society, or who, in the opinion of the Council, expressed by a two-thirds vote of the entire Council shall have been guilty of conduct rendering him unfit to continue in its membership; and the Council may expel such person and remove his name from the list of members.

THE COUNCIL

C 20. The affairs of the Society shall be managed by a Board of Directors chosen from among its Members and Associates, which shall be styled "The Council." The Council shall consist of the President of the Society, who shall be the presiding officer, the two Vice-Presidents, Treasurer and fifteen Members and Associates. Seven Members of the Council shall constitute a quorum for the transaction of business. The Secretary may take part in the deliberations of the Council, but shall not have a vote therein.

C 21. The Council thus constituted shall regulate its own proceedings and shall be the legal Trustee of the Society. All gifts or bequests not designated for a specific purpose shall be invested by the Council and only the income therefrom may be used for current expenses.

C 22. Should a vacancy occur in the Council or in any elective office except the presidency, through death, resignation or other cause, the Council may elect a Member or Associate to fill the vacancy until the next annual election.

C 23. The Council shall present at the Annual Meeting of the Society a report, verified by the President or treasurer or by a

majority of the members of the Council, showing the whole amount of real and personal property owned by the Society, where located and where and how invested, and the amount and nature of the property acquired during the year immediately preceding the date of the report, and the manner of the acquisition; the amount applied, appropriated or expended during the year immediately preceding such date, and the purpose, objects or persons to or for which such applications, appropriations or expenditures have been made; also the names and places of residents of the persons who have been admitted to membership in the Society during the last year, which report shall be filed with the records of the Society, and an abstract thereof shall be entered in the minutes of the proceedings of the Annual Meeting.

C 24. An act of the Council which shall have received the expressed or the implied sanction of the membership at the next subsequent meeting of the Society shall be deemed to be the act of the Society, and shall not afterward be impeached by any member.

C 25. The Council may, by two-thirds vote of the members present, declare any elective office vacant, on the failure of its incumbent for one year, from inability or otherwise, to attend the Council meetings, or to perform the duties of his office, and shall thereupon appoint a Member or Associate to fill the vacancy until the next Annual Meeting. The said appointment shall not render the appointee ineligible to election to any office.

OFFICERS

C 26. At each Annual Meeting there shall be elected from among the Members and Associates:

A President to hold office for one year.

Two Vice-Presidents, one to hold office for one year and one to hold office for two years. After the first year one Vice-President to be elected annually for a term of two years.

A Treasurer to hold office for one year.

Fifteen Members or Associates shall be members of the Council, five being elected each year, and each to hold office for three years, with the exceptions contained in this paragraph. On the year of acceptance of this amendment (1912), in order to increase the number of Directors from nine, as heretofore, to fifteen, as provided in this paragraph and in amended Section C 20, nine Members or Associates shall be elected to the Council, five to hold office

for three years, two to hold office for two years, two to hold office for one year,, thereafter five Members or Associates shall be elected each year.

C 27. The election of officers shall be by ballot, as the By-Laws shall provide.

C 28. The terms of all elective officers shall begin on the adjournment of the Annual Meeting of the Society. Officers shall continue in their respective offices until their successors have been installed.

C 29. A President or Vice-President shall not be eligible for immediate re-election to the same office at the expiration of the term for which he was elected.

C 30. The Council, at its first meeting after the Annual Meeting of the Society, shall appoint a Member or Associate to serve as Secretary of the Society subject to the pleasure of the Council. The Secretary shall receive a salary which shall be fixed by the Council at the time of appointment.

C 31. The President, Secretary and Treasurer shall perform the duties legally or customarily attaching to their respective offices under the laws of the State of New York, and such other duties as may be required of them by the Council.

C 32. A vacancy in the office of President shall be filled by the Vice-President who is senior by age.

MEETINGS

C 33. The Society shall hold its Annual Meeting in New York City on the Monday preceding the first Tuesday in December, and such other meetings shall be held at such times and places as the Council may appoint. Twenty-five Members and Associates shall constitute a quorum for the transaction of business.

C 34. Special meetings of the Society may be called at any time at the discretion of the Council or shall be called by the President upon the written request of twenty-five members entitled to vote.

C 35. Any appropriation recommended by the Society at a meeting shall not take effect until it has been approved by the Council.

C 36. Every question which shall come before a meeting of the Society or of the Council or of a committee shall be decided by a majority of the votes cast, unless otherwise provided in this

Constitution or the By-Laws, or the Laws of the State of New York. The Council may order the submission of any question to the membership for discussion by letter ballot. Any meeting of the Society at which a quorum is present may order the submission of any question to the membership for discussion by letter ballot.

STANDING COMMITTEES

C 37. The standing committees of the Society shall be:
Finance Committee.
Publication Committee.
Membership Committee.

The members of these committees shall be appointed by the President from members of the Council who are not officers of the Society.

TRANSACTIONS

C 38. The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings. Matters relating to politics, religion or purely to trade shall not be discussed at a meeting of the Society nor be included in the Transactions.

C 39. The Society shall not approve any engineering or commercial enterprise, nor allow its imprint or name to be used in any commercial work or business. No member shall describe himself in connection with the Society in any advertisement other than as a Member, Associate Member or Junior Member.

AMENDMENTS

C 40. At annual meetings of the Society any Member or Associate may propose in writing for discussion an amendment to this Constitution. Such proposed amendment shall not be voted on at that meeting but shall be open for discussion and such modification as may be accepted by the proposer. The proposed amendment shall be mailed by the Secretary to each Member and Associate at the time the notice of the next Annual Meeting issues, and shall be voted upon at said meeting.

C 41. Such By-Laws shall be enacted as will conform with this Constitution and the Laws of the State of New York and as are required to conduct the business of the Society.

BY-LAWS

CANDIDATES FOR MEMBERSHIP

B 1. A candidate for admission to the Society as a Member or as an Associate must make application on a form approved by the Council, upon which he shall write a statement giving a complete account of his qualifications and engineering experience, and an agreement that he will, if elected, conform to the Constitution, By-Laws and Rules of the Society. He must refer to at least four Members or Associates to whom he is personally known.

B 2. Applications for membership from Refrigerating Engineers who are not residents in the United States or Canada and who may be so situated as not to be personally known to four Members or Associates of the Society, as required in the foregoing paragraph, may be recommended for ballot by four members of the Council, after sufficient evidence has been secured to show that in their opinion the applicant is worthy of admission to the grade which he seeks.

B 3. A candidate for admission to the Society as a Junior must make application in the same manner as provided for Members or Associates, except that he must refer to not less than three Members or Associates to whom he is personally known.

B 4. The references for each candidate for admission to the Society shall be requested to make a confidental communication to the Membership Committee, setting forth in detail such information, personally known to the referee, as shall enable the Council to arrive at a proper estimate of the eligibility of the candidate for admission to the Society.

ELECTION OF MEMBERS

B 5. The Secretary shall mail to each member entitled to vote, at least thirty days in advance of any meeting, a ballot stating the names and the respective grades of the candidates for membership in the Society which have been approved by the Council and the time of the closure of voting. The voter shall prepare his ballot by crossing out the names of candidates rejected by him, and shall enclose said ballot in a sealed blank ballot envelope, which he shall then enclose in a second sealed outer envelope on which he shall, for identification, write his name in ink. The ballot thus prepared and enclosed shall be mailed or delivered unopened to the Tellers of Election. The Secretary shall certify to the com-

petency and the signature of all voters. On the closure of voting, the Tellers of Election shall first open and destroy the outer envelopes, and shall then canvass the ballots, and certify the result to the meeting of the Society.

B 6. The Tellers of Election shall not receive any ballot after the stated time of the closure of voting. A ballot without the endorsement of the voter written in ink on the outer envelope is defective, and shall be rejected by the Tellers of Election.

B 7. The names of those persons elected to membership, with their respective grades, shall be embodied in a written report, signed by the Tellers, and presented to the next meeting of the Society. The President shall then declare them duly elected to membership in the Society. The Tellers may, through the Secretary, in advance of any meeting, advise each candidate of the result of the canvass of the votes in his case. The names of applicants who are not elected shall neither be announced nor recorded in the Transactions.

B 8. The endorsers of an applicant who has not been elected may, with his consent, present to the Council a written request for a re-submission of his name to ballot. The Council may, in its discretion, by a three-fourths vote of the members present order the name of the applicant placed on the next ballot for members.

B 9. Each person elected to membership must subscribe to the Constitution, By-Laws and Rules of the Society, and pay the initiation fee before he can receive a certificate of membership in the Society.

ELECTION OF OFFICERS

B 10. The Secretary shall mail to each member entitled to vote, at least thirty days before the Annual Meeting, the names of the candidates for office proposed for election by the Nominating Committees.

B 11. The names of the candidates proposed by the Nominating Committee or Committees, and the respective offices for which they are candidates, shall be printed in separate lists on the same ballot sheet, each list of candidates to be printed under the names of the members of the particular committee which proposed it.

B 12. The name of any candidate on the ballot may be erased, and the name of any person qualified to hold the office written in its stead. The ballot must be voted and canvassed in the same manner as for the election of members.

B 13. In case of a tie in the vote for any office, the President, or, in his absence, the Presiding Officer, shall cast the deciding vote.

B 14. A ballot which contains more names on it than there are officers to be elected is thereby defective, and shall be rejected by the Tellers.

FEES AND DUES

B 15. The initiation fee and annual dues of the first year shall be due and payable on notice of election to membership. Thereafter the annual dues shall be due and payable on the first day of December in each year.

B 16. A Member in arrears for one year shall not be entitled to vote until such arrears have been paid. Should the right to vote be questioned, the books of the Society shall be conclusive evidence.

B 17. The Secretary shall present to the Council the name of any Member, Associate or Junior in arrears for more than one year. A person dropped from the rolls for non-payment of dues may, at the discretion of the Council, be restored to the privileges of membership upon payment of all arrears.

FINANCIAL ADMINISTRATION

B 18. The Council at its first meeting in each fiscal year shall consider the recommendations of the Finance Committee concerning the expenditures necessary for the work of the Society during that year. The apportioning of the work of the Society among the various standing and other committees shall be on a basis approved by the Council and in harmony with the Constitution and By-Laws. The appropriations approved by the Council, or so much thereof as may be required for the work of the Society, shall be expended by the various committees of the Society, and all bills against the Society for such expenditures shall be certified by the committee making the expenditure and shall then be sent to the Finance Committee for audit. Money shall not be paid out by any officer or employee of the Society except upon bills duly audited by the committee, or by resolution of the Council.

FINANCE COMMITTEE

B 19. The Finance Committee shall consist of three mem-

bers of the Council appointed for a term of one year. The committee shall, under the direction of the Council, have supervision of the financial affairs of the Society, including the bboks of account.

PROGRAM COMMITTEE

B 20. The President shall appoint a Program Committee from the members of the Council which shall procure professional papers, pass upon their suitability for presentation, and to suggest topical subjects for discussion at the meetings. The committee may refer any paper presented to the Society to a person or persons, especially qualified by theoretical knowledge or practical experience, for their suggestions or opinions as to the suitability of the paper for presentation. Papers from non-members shall not be accepted except by unanimous vote of the committee. The committee shall arrange the program of each meeting of the Society, and shall have general charge of the entertainments to be provided for the members and guests at each meeting. It shall prohibit the distribution or exhibition at the headquarters or at the meeting places of the Society of all advertising circulars, pamphlets or samples of commercial apparatus or machinery. At the end of each fiscal year the committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

PUBLICATION COMMITTEE

B 21. The Publication Committee shall consist of three members of the Council appointed for a term of one year. The committee shall review all papers and discussions which have been presented at the meetings, and shall decide what papers or discussions, or parts of the same, shall be printed. At the end of each fiscal year the committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

MEMBERSHIP COMMITTEE

B 22. The Membership Committee shall consist of three members of the Council appointed for a term of one year. It shall be the duty of this committee:

To receive and scrutinize all applications for membership to the Society.

To seek further information as to the qualifications of any applicant whose evidence of eligibility is not clear to the committee.

To report to each session of the Council the names of all applicants under consideration, together with the action of the committee on each.

The committee shall at once destroy all correspondence in relation to each applicant when his name has been placed on the ballot by order of the Council, or upon the withdrawal of the application.

NOMINATING COMMITTEES

B 23. A Nominating Committee of five Members or Associates shall be appointed by the President within three months after he assumes office. It shall be the duty of this committee to send to the Secretary on or before October first the names of consenting nominees for the elective offices next falling vacant under the Constitution. Upon the request of any Member or Associate, the Secretary shall furnish to the applicant the names of such nominees.

B 24. Twenty or more members entitled to vote may constitute themselves a Special Nominating Committee with the same powers as the Annual Nominating Committee. A Special Nominating Committee, if organized, shall, on or before October twentieth, present to the Secretary the names of the candidates nominated by it for the elective offices next falling vacant under the Constitution, together with the written consent of each.

TELLERS

B 25. The Presiding Officer shall, at the first session of the Annual Meeting, appoint three Tellers of Election of Officers, whose duties shall be to canvass the votes cast, and report the result to the meeting. Their term of office shall terminate when their report of the canvass is presented to the meeting.

B 26. The President within one month after assuming office shall appoint three Tellers of Election of Members to serve for one year, whose duties shall be to canvass the votes cast for members during the year, and to certify the same to the President. They shall notify candidates through the Secretary of the result of such election.

B 27. The President shall appoint three Tellers to canvass any letter ballots which shall be ordered by the Council or by the Society.

SECRETARY

B 28. The Secretary of the Society shall be the Secretary to the Council.

The Secretary shall, under the supervision of the Finance Committee, have charge of the Books of Account of the Society.

He shall make and collect all bills against members or others.

All bills against the Society shall be delivered to the Secretary. He shall immediately enter them in the books of Account, and shall immediately deposit such funds as he receives to the credit of the Society in a bank to be designated by the Council.

TREASURER

B 29. The Treasurer shall make payments only on the audit of the Finance Committee, or upon the direction of the Council by resolution of that body. He shall furnish a bond for the faithful performance of his duties to such amount as the Council may require, such bond to be procured from an incorporated guarantee company at the expense of the Society.

TITLES, EMBLEMS, CERTIFICATES

B 30. Each Member, Associate and Junior, subject to such rules as the Council may establish, shall be entitled on request to a certificate of membership signed by the President and Secretary of the Society. Every such certificate shall remain the property of the Society, and shall be returned to it on demand of the Council.

B 31. Each proxy authorizing a person to vote for an absent member shall be signed by such absent member, with an attesting witness, and be submitted to the Secretary for verification of the member's right to vote at the meeting at which the right is to be exercised.

B 32. The emblem of each grade of membership approved by the Council shall be worn by those only who belong to that grade. The official stationery shall be used only by Officers and Committees of the Society for official business.

B 33. The abbreviations of the titles of the various grades of membership approved by the Society are as follows:

For Members—Mem. Am. Soc. R. E.

For Associates—Assoc. Am. Soc. R. E.

For Juniors—Jun. Am. Soc. R. E.

ORDER OF BUSINESS

B 34. Roll Call.
Reading of Minutes of previous meeting.
Report of Tellers of Election of Members.
Report of the Council.
Unfinished business.
New business.
Report of Tellers of Election of Officers.
Reading of papers and discussions.

PARLIAMENTARY RULES

B 35. In all questions arising at any meeting involving parliamentary rules not provided for in these By-Laws, "Cushing's Manual" shall be the governing authority.

AMENDMENTS

B 36. These By-Laws may be amended in the same manner as amendments are made to the Constitution.

PROCEEDINGS

OF THE

THIRD WESTERN MEETING

CHICAGO, ILL., September 18, 1913.

The American Society of Refrigerating Engineers held its Third Western Meeting in the Hotel La Salle, Chicago, Ill., on Thursday afternoon, September 18, 1913, and concurrent with the Third International Congress of Refrigeration, with President Peter Neff, Canton, Ohio, presiding.

The reason for holding only one session at this meeting was to give the members of the Society as much time as possible to participate in the sessions of the various sections of the Congress. A good part of the success of the Congress was due to the co-operation and activities of a large part of the membership of The American Society of Refrigerating Engineers. Of the many papers presented before the Congress, the following were by members of this Society:

Comparative Installation and Operating Cost of a Combined Ice Manufacturing and Cold Storage Plant. R. H. Tait and L. C. Nordmayer.

Compressed Exhaust Steam for Ice Making and Refrigeration. Gardner T. Voorhees.

Critical Point of CO_2: A Possible New State of Matter. Gardner T. Voorhees.

Multiple Effect Compressors and Multiple Effect Receivers. Gardner T. Voorhees.

Local Cold Storage Warehouses in Canada. J. A. Ruddick.

Pipe Line Refrigeration. G. F. Bein.

Air Cooling and Dehumidifying. J. I. Lyle.

Cost of Manufacture in Distilled Water Ice Plants. Peter Neff.

Theory and Practice of Using Ice in Transit to Prevent Freezing of Perishable Goods. Peter Neff.

Handling Manufactured Ice at Icing Stations. Harold B. Wood.

Effectiveness of Existing Laws Regulating Cold Storage Warehouses and Products. Frank A. Horne.

Exhaust Steam Absorption Proposition. N. H. Hiller.

As more than 200 members and guests were in attendance, the calling of the roll of membership was dispensed with.

The reading of the minutes of the Eighth Annual Meeting was postponed until the Ninth Annual Meeting.

The report of the Tellers of Election of Members was now received. It was as follows:

REPORT OF THE TELLERS OF ELECTION OF MEMBERS

New York, N. Y., May 16, 1913.

MR. PETER NEFF, President,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York, N. Y.

Dear Sir:—Your Tellers of Election of Members met on Friday afternoon, May 16, and canvassed the ballots for new members that closed on April 15 and beg to report that 134 ballots were cast, 5 of which were void, leaving 129 effective ballots. We found that the following applicants for membership were duly elected in the grades indicated:

MEMBERS

Sydney B. Carpenter, New Brunswick, N. J.
J. I. Lyle.....New York, N. Y.
Norman M. Small..Waynesboro, Pa.
Herbert E. Smith....Boston, Mass.

ASSOCIATE MEMBERS

William H. Dohrmann, Brooklyn, N. Y.
W. L. Glatfelter.....York, Pa.
Arthur Gifford.....Hudson, N. Y.
Charles J. Hackett..Brooklyn, N. Y.
Francis S. Russell.....Chicago, Ill.

JUNIOR MEMBERS

Frederick J. Byrne.New York, N. Y.
Gilbert H. Crawford, Jr., Washington, D. C.
E. Montague Frid..Philadelphia, Pa.
Guy W. Jacobs.....York, Pa.
L. A. Ramsey.....New York, N. Y.
Clarence W. Vogt...Louisville, Ky.

Very truly,

(Signed) GEO. H. LANE, *Chairman*,
ROBT. N. BAVIER,
JOHN R. LIVEZEY.
} *Tellers of Election of Members*

President Neff formally declared the successful applicants duly elected to membership in their respective grades.

Under the head of unfinished business President Neff called for a report from the Committee on Suggesting a Standard Tonnage Basis of Refrigeration and Standard Method of Testing Refrigerating Machinery, to Act Jointly with a Similar Committee of the American Society of Mechanical Engineers. Louis Block, New York, N. Y., who reported for the committee, stated that the committee had begun its work several years ago and, with other organizations, had succeeded in interesting the National Government to the extent that the Bureau of Standards at Washington, D .C., was now determining the physical constants employed in refrigerating engineering. He further reported that as soon as the Bureau of Standards completes its work, the Committee would again take up the duty assigned to it.

A report from the Physical Constants Committee was next in order and Louis Block also reported for this committee. He reported that the Bureau of Standards, at Washington, D. C., has this work under way. He further stated that representatives of the Bureau of Standards have traveled over the country inquiring what work they should take up first and they found that the first thing we should know was the actual heat of fusion of ice. and, after extensive investigations, the Bureau of Standards has determined that it should be 143.5 B. t. u. He also stated that the Bureau of Standards was determining the specific heat of ice and that it was also intended to determine the transmission of heat through various metals and materials under various conditions.

The report of the Committee on Temporary Physical Constants was next received. Van R. H. Greene, New York, N. Y., stated that, as the Bureau of Standards is now actually determining the physical constants employed in refrigerating engineering, it seemed unwise at the present time to make any suggestions as to temporary physical constants.

The report of the Committee on Standardization of Ammonia Fittings was made by Thomas Shipley, York, Pa. Mr. Shipley stated that the members of his committee and the members of a similar committee of the American Association of Refrigeration had met in Pittsburgh on June 19 and considered the matter of standardization of ammonia fittings. He stated that they had arrived at the point where it was necessary to have a report from each manufacturer of fittings as to the details of design of all fittings. He further stated that there was a question in the mind of his committee whether it was advisable to standardize ammonia fittings.

The Committee on Suggesting a Standard Basis for Finding the Fuel Economy of Steam Driven Ice Plants reported through N. H. Hiller, Carbondale, Pa., its chairman. Mr. Hiller reported that his committee had held a meeting in August and had discussed whether economy should be based upon the fuel consumption or steam consumption. He said the committee decided that the weight of feed water to boiler per ton of ice made was the proper basis. He further stated that one member preferred the fuel consumption basis.

The address of President Neff on "The American Society of Refrigerating Engineers" was now received with close attention.

The following topics were discussed at length: "Raw Water Ice" and "Recent Types of Ammonia Condensers and Their Efficiencies."

The meeting then adjourned.

W. H. Ross, *Secretary.*

MEMBERS AND GUESTS ATTENDING THIRD WESTERN MEETING

Adams, E. E., St. Louis, Mo.
Alderman, E. W., Milwaukee, Wis.
Allen, G. H., Chicago, Ill.
Allen, John R., Ann Arbor, Mich.
Alley, F. H., Nashville, Tenn.
Allin, James C., Nashville, Tenn.
Armour, Norman H., Chicago, Ill.
Atwood, John C., St. Louis, Mo.
Baars, Ernst S. H., Milwaukee, Wis.
Baer, A. H., Waynesboro, Pa.
Baily, James, Chicago, Ill.
Baker, Charles A., Niagara Falls, N. Y.
Baldno, Ignatz, Indianapolis, Ind.
Ball, P. D. C., St. Louis, Mo.
Bardenheuer, William C., Chichago, Ill.
Becker, V. H., St. Louis, Mo.
Bein, G. F., Fort Worth, Texas.
Berger, Charles A., Minneapolis, Minn.
Berton, Leon, Helena, Ark.
Block, Louis, New York, N. Y.
Borchers, Herbert, L., Portsmouth, O.
Borodin, N., St. Petersburg, Russia.
Bracken, John H., Chicago, Ill.
Broas, Richard, New York, N. Y.
Brooks, Thomas, New Castle, Pa.
Brownell, C. H., Washington Court House, O.
Burhorn, Edwin, New York, N. Y.
Carpenter, M. R., Cincinnati, O.
Cochran, Heywood, Chicago, Ill.
Cole, Harold W., New York, N. Y.
Cole, Ralph N., Canton, Ohio.
Criswell, A. P., Chicago, Ill.
Delle, Frank A., St. Louis, Mo.
Dettmar, E., Chicago, Ill.
Dickinson, H. C., Washington, D. C.
Dreyer, Oscar, Saratov, Russia.
Estebanez, B. A., New York, N. Y.
Flaherty, J. F., Chicago, Ill.
Frick, Ezra, Waynesboro, Pa.
Gallenkamp, E. W., Jr., St. Louis, Mo.
Garauthe, W. B., Carthage, Mo.
Gifford, Arthur, Hudson, N. Y.
Glatfelter, W. L., York, Pa.
Goosmann, J. C., Chicago, Ill.
Greene, Van R. H., New York, N. Y.
Harris, H. Gordon, Kansas City, Mo.
Heckendorn, W. S., Flandreau, S. D.
Heise, Ernest B., Orleans, Ind.
Hesse, Bert. F., Chicago, Ill.
Hexamer, W. E., Philadelphia, Pa.
Hill, F. W., Boston, Mass.
Hill, J., New York, N. Y.
Hill, Walter L., Boston, Mass.
Hiller, N. H., Carbondale, Pa.
Hoffman, C. E., Houston, Texas.
Hoffmann, W. John, Brooklyn, N. Y.
Horne, Frank A., New York, N. Y.
Horne, George A., New York, N. Y.
Hutchinson, Arthur, J., New York, N. Y.
Ilyachenko, M., Moscow, Russia.
Jacobus, D. S., New York, N. Y.
Jamison, J. V., Hagerstown, Md.
Johnson, Albert, Chicago, Ill.
Kaiger, C. J., New York, N. Y.
Karl, Robert H., St. Louis, Mo.
Kavan, Joseph, Prague, Austria.
Kerbel, C. Joseph, Louisville, Ky.
Kilian, Justus, Milwaukee, Wis.
Kleucker, George M., St. Louis, Mo.

Koch, Alexander, Vienna, Austria.
Kolischer, Theodore,
Philadelphia, Pa.
Kuenen, J. P., Leiden, Holland.
Laichinger, John, St. Louis, Mo.
Lane, George H., New York, N. Y.
Lewis, Eugene W., Chicago, Ill.
Linde, Dr. F., Munich, Germany.
Luhr, Otto, Chicago, Ill.
Lyle, J. I., New York, N. Y.
MacColl, S. H., Winnipeg, Canada.
Manns, W. H., Waynesboro, Pa.
Marshall, A. T., Hartford, Conn.
Massa, R. F., Fort Wayne, Ind.
Mason, W. B., Providence, R. I.
May, W. J., New York, N. Y.
McCandlish, R. M., Kansas City, Mo.
McDaniel, Homer, Cleveland, Ohio.
McPartlin, S. E., Chicago, Ill.
McPike, E. F., Chicago, Ill.
Mikkelson, W. H., Chicago, Ill.
Miller, Edward F., Boston, Mass.
Mohr, Leonard, Columbus, Ohio.
Moore, Herbert, Memphis, Tenn.
Morse, Louis S., York, Pa.
Mosher, William Earl,
Washington, D. C.
Mott, Walter, Chicago, Ill.
Neeson, C. R., New York, N. Y.
Neff, Peter, Canton, Ohio.
Nickerson, J. F., Chicago, Ill.
Nifong, R. C., Kansas City, Mo.
Nifong, W. R., Kansas City, Mo.
Nolde, Fred, Philadelphia, Pa.
Nordmeyer, L. C., St. Louis, Mo.
O'Brien, D. F., Jr., Chicago, Ill.
Ohle, Ernest, St. Louis, Mo.
Parsons, W. Everett,
New York, N. Y.
Patitz, G. J., Chicago, Ill.
Paul, George, Richmond, Va.
Pearce, M. K., Bagalusa, La.
Perrine, C. H., Chicago, Ill.
Perry, Allen M., Chicago, Ill.
Phillips, W. C., San Francisco, Cal.
Polley, W. F., Columbus, Ohio.
Pownall, H. D., Canton, Ohio.
Quinn, R. J., Chicago, Ill.
Rasbury, J. A., Atlanta, Ga.
Rjasanzeff, A.,
St. Petersburg, Russia.
Roos, Frank J., Chicago, Ill.
Ross, W. H., New York, N. Y.
Rugh, H. A., New Castle, Pa.
Satkevich, A., St. Petersburg, Russia.
Schadek, E. W., St. Louis, Mo.
Schlegelmilch, G. E.,
Philadelphia, Pa.
Schmidt, C. R., Baltimore. Md.
Schoephoester, George W.,
St. Louis, Mo.
Schoonmaker, M., Chicago, Ill.
Schroeder, Charles, Chicago, Ill.
Schulte, Charles F., St. Louis, Mo.
Shipley, Thomas, York, Pa.
Shipley, William S.,
New York, N. Y.
Sieben, Theodore S., Chicago, Ill.
Smyth, S. F., Brooklyn, N. Y.
Sparks, John C., New York, N. Y.
Stahl, A. J., La Porte, Ind.
Stephens, L. H., Jr., St. Louis, Mo.
Stevenson, S. P., Chester, Pa.
Stolbin, V. L., Orenburg, Russia.
Stratton, Harrison, D.,
Philadelphia, Pa.
Strickler, A. B., York, Pa.
Sutton, W. S., New York, N. Y.
Sweet, Will D., Siloam Springs, Ark.
Switzler, R. H., St. Louis, Mo.
Tait, R. H., St. Louis, Mo.
Taylor, Walter A., Hammond, La.
Torrance, Henry, Jr.,
New York, N. Y.
Tratman, E. E. R., Chicago, Ill.
Tsulsumi, H., Tokio, Japan.
Vaiden, G., Williamsburg, Va.
Van Der Vaart, S. S., Chicago, Ill.
Vaughan, Tom, Chicago, Ill.
Vesterdahl, Karl, New York, N. Y.
Vilter, Emil, Milwaukee, Wis.
Vilter, Theodore, O.,
Milwaukee, Wis.
Vilts, Charles J., Cleveland, O.
Vogt, Clarence W., Louisville, Ky.
Vogt, Henry, Louisville, Ky.

Vollman, C. W., Montreal, Canada.
Von Weise, L. B., St. Louis, Mo.
Voorhees, Gardner T., Boston, Mass.
Waite, Nelson J., Cleveland, Ohio.
Wallber, Hilber C., Milwaukee, Wis.
Wells, George E., St. Louis, Mo.
Westerlin, J. M., Chicago, Ill.
Wharton, J. R., Columbia, Mo.
Whittemore, C. L., St. Louis, Mo.
Williams, E. T., New York, N. Y.
Wilson, Thomas, New York, N. Y.
Winborg, W., York, Pa.
Wittenmeier, Fred, Chicago, Ill.
Wolf, George P., Chicago, Ill.
Wood, Harold B., Hudson, N. Y.
Wood, R. O., Lima, Ohio.
Wu Ying, Washington, D. C.
Young, C. H., Pittsburgh, Pa.
Zielke, Paul, Brooklyn, N. Y.

PAPERS IN VOLUME IX

No.	Author.	Title of Paper	Page
113.	Peter Neff.	Presidential Address—The American Society of Refrigerating Engineers	31
114.	*Discussion.*	Raw Water Ice	36
115.	*Discussion.*	Recent Types of Ammonia Condensers and Their Efficiencies	68
116.	Peter Neff.	Presidential Address	107
117.	Max von Recklinghausen.	The Sterilization of Water by Ultra-Violet Rays	112
118.	Eugene F. McPike.	The Refrigerator Car—Retrospective and Prospective	125
119.	J. H. Bracken.	The Refrigerator Car—Retrospective and Prospective	137
120.	John C. Sparks.	Chemistry of Raw Water Can Ice	159
121.	C. H. Stevens.	Electricity for Ice Making and Refrigeration as Supplied by the Central Station	173
122.	J. L. Hughes.	Fruits—Their Handling and Storage	203
123.	Ernst S. H. Baars.	A Review of the Feed Systems of Refrigerating Coils and Their Respective Advantages	216
124.	Charles H. Herter.	Defining the Heat Conductivity of Insulators	230
125.	*Discussion.*	Ammonia Purifiers or Regenerators and Foreign Gases in Refrigerating Systems	259

PAPERS

OF THE

THIRD WESTERN MEETING

CHICAGO, ILL., SEPTEMBER 18, 1913.

No. 113

PRESIDENTIAL ADDRESS—THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.

By Peter Neff, Canton, Ohio

It is impossible to name the date when refrigeration as an engineering possibility had its beginning. We find it very early classed with physics and chemistry, but as mechanical devices became necessary to its development it became a part of mechanical engineering. Then to the term refrigeration was attached the word mechanical, and as mechanical refrigeration it is frequently referred to even to-day.

The affiliation with mechanical engineering continued for many years, but the problems to be solved became more and more complex, now going off into the realm of physics and chemistry, and again becoming a part of that wide field covered by civil engineering, so that those devoting their lives to this subject found that they had no abiding place, being a part of many organizations, covering widely different fields of activity.

The result was that refrigerating engineers either associated together at the meetings of the various organizations to which they belonged, for the purpose of friendly discussion among themselves of topics often of no general interest to that particular organization, or they did not affiliate with any organization. In the latter case they often worked alone, frequently covering the same ground that had been traveled by others, developing a characteristic individualism, which, more than anything else, retarded the development of the industry in the early days of its existence.

Everyone must build on the knowledge and experience of others, and this cannot be done except through organization and association with others engaged in like work.

Not until 1890 did it become apparent that refrigeration was a necessary factor in the existence of human life, and so, during the decade that followed, business men began to realize that here was a field for financial investment.

The need of coöperation was keenly felt by manufacturers of refrigerating apparatus and others, and attempts at standardization were made; the value of literature was realized, and trade papers became a medium of communication. Still, the refrigerating engineer did not develop as he should. His ideas and practices were set forth and criticised by those from whom he obtained little, if any, benefit; on the contrary, it made him more reticent and his

opinion of others engaged in like work was colored by the representations of salesmen.

This period was truly the dark ages of the refrigerating engineer. The awakening came through men engaged in the industry who were brought in contact with others pursuing similar work. At about 1900 a movement had begun which culminated in the birth of an association in 1904. That year a few refrigerating engineers in New York City decided that the time was opportune for effecting an organization. A call was sent out and seventy-four favorable responses were received. These became the charter members of The American Society of Refrigerating Engineers, the only institution in the world confining itself solely to the problems of refrigeration.

The committee appointed to draft a constitution went to work in a systematic manner, taking from articles of association of this and that organization such features as were applicable to their needs and building up an instrument adapted to the requirements of this comparatively new engineering body. The result of their labors was a constitution which so far has stood every test put upon it, and there is no doubt that it will remain a lasting tribute to their foresight, diligence and ability.

The first annual meeting of the Society was held December, 1905. It was well attended and aroused so much enthusiasm that the future success of the Society was assured. This has been amply verified by subsequent events.

From the seventy-four charter members the Society has grown until its register shows that three hundred and fifty-three have been admitted to membership. Deaths and a few resignations have reduced this number to two hundred and ninety-five, now the active roster.

Membership in the Society is divided into three classes, known respectively as Member, Associate and Junior. While the class of Member is one which embraces those who, to a greater or less degree, combine all the functions of a refrigerating engineer, the Associate, on the other hand, with equal privileges in the Society, may be a specialist in many correlated branches of refrigerating engineering, or, simply by his training, able to give valuable assistance to refrigerating engineers. The Junior class enables those who are being trained in the art of refrigeration to receive the benefits that association can give.

Numerical strength alone does not inspire confidence. Something else is required. Let us see what the Society has accomplished and if it has lived up to the opening statement of its constitution—"to promote the arts and sciences connected with refrigerating engineering!"

The annual meeting is held in New York City in the month of December, and every other year a mid-year meeting is held in some Western city. Each of several sessions.

At these meetings papers on various topics connected with the industry are presented. After the papers are read they are discussed, and here is where the greatest good to the member is developed, as an exchange of views often serves to enlighten what might otherwise be obscure in the papers themselves. The mere reading of papers will not bring out the important facts as forcefully as will the discussions, or, better, the taking part in them.

The papers and their discussion make up the Society's Transactions, and these are published annually in a handsomely bound volume. To anyone interested in refrigeration these Transactions are invaluable and must be continually consulted if one would keep pace with what is being done in the industry.

A glance through the index of these Transactions will reveal a diversity of subjects fully in keeping with the vastness and importance of the industry. It is not possible here to give even a partial list of the subjects treated. It can be said, however, that these Transactions are the greatest contributions to the literature on refrigeration.

Personal attendance at the meetings has served to remove from the minds of the members any possible feeling of animosity that might have been entertained against some other member, due, principally, to a too strenuous commercial competition. They have learned to meet as members of an organization the aims and ideals of which are far removed from such strife, and yet the knowledge acquired is the means of advancing their interests.

Refrigerating engineering has always suffered from a lack of basic standards of positive value. The Society has taken the lead in having these standards determined. As this will be a slow process, the Society proposes to promulgate, for the use of engineers, a set of what is termed "Temporary Physical Constants," which will at least tend to unify calculations. These will be of valuable assistance, especially where legal proceedings are involved.

Committees are at work devising a method for conducting tests of ice manufacturing plants, the standardization of ammonia fittings, the suggesting of a standard tonnage basis of refrigeration and a standard method of testing refrigerating machinery. The latter committee is working in connection with a similar committee of The American Society of Mechanical Engineers.

Mr. John E. Starr, the first president of the Society, in his annual address, said: "To define our field in a word, I may say that we claim as our own all that relates to the production of temperatures, below the ordinary, for useful purposes." Of the Society's responsibilities he added: "We have undertaken the responsibility of speaking with authority, of finding the truth and proclaiming it, and a critical world will hold us to our task or pass us by as unworthy." Consciousness of this responsibility has been ever before the Society, causing it to proceed slowly and with great care in all that it has done or undertaken.

The placing before the world of the papers and discussions in its published Transactions is the paramount work of the Society. The bringing together in harmony of its widely scattered members, and sifting their ideas, which are often at variance with those of others, and setting forth the work of the individual as mile-stones of progress, is, of course, of second importance. The thoughtful weighing of evidence and the desire to promulgate standards and methods for the betterment of all interested to any degree in the industry, coupled with the check it has put on the issuance or suggestion of standards and methods by organizations acting with selfish motives, is the third great work of the Society.

While the executive officer of the Society is changed annually, the deep-seated policies broadly laid down by its founders have been adhered to. The Society is only in the ninth year of its existence, yet it stands to-day as the supreme exponent of good refrigerating engineering practice and is regarded by all as the final court of appeal on all questions relating to refrigeration. Its influence for good unquestioned.

While in name the organization is American, its membership is not confined to any one country. Russians, Japanese, Englishmen, Canadians and Australians, as well as those interested in refrigeration in New Zealand, India and South America, are to be found on its list of members.

The Society is now developing its library, which, we hope,

will be the most complete collection of literature on refrigeration extant. This library is accessible to all members of the Society.

An employment bureau has been started for the benefit of all in need of the services of trained men, as well as those seeking employment. This bureau is at the service of members and non-members.

It will soon be the duty of the Program Committee to select the best papers from those voluntarily submitted for presentation, instead of urging their preparation.

We look forward, at no far distant day, when we will be housed in our own building, with an indexed library complete as to works on refrigeration and cared for by a competent librarian; in addition, a clerical force adequate to the needs of the work that has to be done and with a fund large enough to enable the Society to carry on research work.

At that time membership will be eagerly sought by all who are eligible, no matter in what part of the world they may live, and the Society will truly be *the* factor in all that goes to make up refrigerating engineering. The Society will then be fulfilling its manifest destiny.

We are now standing on the threshold of what refrigeration can do for the comfort and happiness of humanity, and The American Society of Refrigerating Engineers holds open wide the door of opportunity and invites you to enter.

No. 114

Discussion of the topic—RAW WATER ICE

President Neff.—I would like to talk a little while on this subject of raw water ice, which is a very interesting one. It naturally divides into two divisions, one covering plate ice, which we have been making for a good many years from raw water, and the other covering raw water ice made in cans. There seems to be growing up a distinction; I think in a great many of us, when we speak of raw water ice, our minds almost instantly revert to the can proposition rather than the plate, that seeming to be a sort of a standard by itself; but in the discussion of this problem, bear in mind that it covers not only raw water ice made on the plate system, but also any other process imaginable. In going over, from time to time, raw water ice plants, a number of different points have come up to me. Most of them, I think, have been overcome, but, just in order to have something to start with, I am going to read a little list of points that have occurred to me and which may or may not have been fully covered and may or not be fully susceptible of explanation. The first is, the irregular pressure or quantity, or both, of the air needed during the different stages of the freezing process. I am not going to discuss these points, but just name them as they have occurred to me. Second, stopping of the air supply by freezing up the supply line, due generally to the presence of moisture in the air. Third, stoppage of the air by freezing up of water in the can while a considerable portion of the water is still unfrozen. Fourth, removal of the impurities contained in the water to be frozen, the majority of which either concentrates in the center or at the top of the can. Fifth, the irregularity of the top of the block of ice, due to the building up of the block by water thrown up by the air. Sixth, the extra labor required on the tanks. Seventh, losses incident to the process, such as removal of core water and refilling, and heat absorption on account of peculiar tank obstruction. Eighth, inability to apply these processes to existing plants, in whole or in part. Ninth, a possible increase in depreciation charge; an increase in first cost. Eleventh, irregular-

ity in the character of output, due to irregular or defective operation of a part of the apparatus upon which quality depends. Twelfth, a combination of losses increasing the horsepower per unit of ice delivered; and lastly, the question as to whether a saving can be shown, when all points are taken into account, over what can be accomplished by the use of steam economy and other devices applicable to distilled water plants.

John C. Sparks.—Mr. President, I would like to take up that first question of yours; the lack of uniformity in air agitation. I don't think that proper consideration is given to the relationship between the amount of air required in raw water can ice and the temperature the brine carries. I have visited a large number of raw water can ice plants lately and in a good many of them poor ice is made. It is usual practise to use, as the source of air, a blower without any regulation of the air pressure. The amount of air has not yet been regulated according to the temperature at which the brine is carried. The lower the temperature of the brine tank, the more air is necessary; the quicker the ice forms, the more air is necessary; the more carbonates in the water, the more air is necessary; the larger the can, the more air is necessary. For instance, I have been to plants where they have 1,200 pound cans, and where they have 600 pound cans, and to plants where they have 300 pound cans. Additional air has not been provided with the larger cans, with lower brine temperature or with different qualities of water.

Louis Block.—Can Mr. Sparks tell us how much air is necessary for 100 pounds of ice?

John C. Sparks.—I am working on that now. It depends on the four factors already itemised, namely, on the temperature of the brine, on the amount of carbon dioxide in the water, which holds the carbonate in solution, on the speed of freezing of the ice and on the size of the can.

H. D. Pownall.—I think that Mr. Sparks is leaving out the one most vital factor, and that is the air blower. There is not an air blower on the market to-day which will deliver within 25 per cent. of the amount of air specified by the manufacturer and, I might state along this line, I have had some experience with air blowers. We sent to one plant of a certain capacity a blower that was guaranteed to deliver 300 cubic feet of air per minute at 3½ pounds pressure. The blower proved entirely too large for the

plant having a given number of cans. We sent another blower of a different make to another plant guaranteed under the same conditions, but for the same number of cans it did not prove to be within 50 per cent of the size required. Now, the question arose as to whether we were furnishing enough air to properly agitate the water or whether the blower was at fault. In order to satisfy ourselves we sent A's blower to B's plant and B's blower to A's plant, and thoroughly demonstrated the fact that the blower was the cause of the trouble. I have also found that the presence of sulphates in the water is a serious matter to contend with, regardless of what Mr. Sparks says. That is my conclusion and conforms with what chemists have told me. Water containing considerable sulphate will require more agitation than water without sulphate. We have come to the positive conclusion that there is only one way to make raw water ice, and that is to remove a majority of the impurities before the water goes into the cans and that can be done in most cases by means of water softening apparatus, such as manufactured by several concerns. My experience during the past several years has so clearly demonstrated to me the advantages of the raw water proposition that I firmly believe that within ten years there will not be a distilled water plant sold in this country. I think such plants will be driven by gas engines, using natural gas or producer gas, or compound condensing engines or oil engines, and if not that source of power, it will be electric power derived from central stations. I think there is a greater field at this time for the electric driven plant receiving its power from the central station than for any other class of power; this being due to the fact that the electric companies have surplus of power in the summer time, when the ice manufacturers need it, and in the winter time, when the ice man does not require it, they can dispose of the power elsewhere and consequently they are in position to give an extremely low rate if one knows how to approach them. Furthermore, the electrically driven plant requires little attention, its initial cost is less, it requires less ground space, and there is less depreciation, therefore, in my estimation the raw water plant is the coming method of ice manufacture.

John C. Sparks.—I entirely agree with the last speaker in regard to the blower. The blower is a very unsatisfactory proposition and does not give enough air. I do not think it is the best method of providing the air. On the question of sulphate, I would

like to ask how, in any method of purification, the sulphate can be removed without producing sodium sulphate as a by-product, as a secondary product, and thereby removing the opaque core from the center of the can to the outside of the can? If you produce sodium sulphate, you just move your core to the outside of the can. Will you tell me how the sulphate can be removed without producing sodium sulphate as a by-product?

H. D. Pownall.—I did'nt quite catch that.

John C. Sparks.—If you remove any of the sulphate of lime or magnesium, you have to make a substitution product, and, in making it, is it possible to do so without making the sulphate of soda? And if you do that, the crystals of sulphate of soda have a higher critical temperature than the crystals of water, so consequently you get sodium sulphate deposited on the outside of the ice cake instead of in the core of the ice. I would like to know what system of purification would remove the sulphate and prevent that condition.

H. D. Pownall.—I am not a chemist, and when I make the statement that sulphates are a source of trouble in raw water ice, I am influenced by what three of the water-softening companies maintain, and the problems have been submitted to them. I can only state that by treating the water with hydrate of lime, that they have succeeded in removing from the water the impurities which they pronounced as magnesium sulphate and have succeeded in producing a clear block of ice where we were unable to produce it before. In the process that we use, the water is circulated into and from the cans at the rate of about three-fifths of a gallon per minute per can, and at the end of the freeze all of the impurities are found in what we term the precipitating tanks.

John C. Sparks.—So you really do not freeze your core?

H. D. Pownall.—We freeze the block of ice solid.

John C. Sparks.—But you have the real core left in the other tank?

H. D. Pownall.—All the impurities are deposited outside of the can which contains the water being frozen. When the ice is so frozen—we will assume a 300-lb. block of ice—that there only remains about ten pounds of water in the can, we open one valve that controls the drainage from sixty cans, and drain out the core water and refill with distilled water or fresh raw water, but having

previously closed off the air, we thus complete the freezing of the block without agitation. In this manner we produce a practically coreless block of ice.

Louis Block.—I am sorry to say that I do not agree with Mr. Pownall at all in any one of his propositions. I think we have simply been driven to make raw water ice because we have not been able to make a pure, odorless, distilled water can ice. The proposition of applying electricity for driving an ice plant is so far distant that we cannot think of it to-day. Whether it will come in ten years or in fifty years, we do not know. At the present moment it is not possible in the United States to buy electricity at any cost which comes near the cost of producing power with your own plant. The making of raw water can ice I have always called "making" ice. It is not manufacturing; you have got to fuss with it in order to get it right, and you are very often at a loss to get it right. As Mr. Pownall says, you drain out the last ten or fifteen pounds of water and then fill with distilled water; that means that you must have a distilled water plant any way. If you can make can ice, which is a pure manufacturing proposition, and can make it so that no objection can be found by anybody, a slight core in the center is no objection, then I think the can ice plant is the one which is most rational in all countries where can ice has been used. Any country where they want plate ice, as where people have been accustomed for a long time to natural ice they want plate ice, then give it to them; but when you come to the rest of this country, where they want can ice, give them that. When the consumers get a 50-lb. piece of ice, they want to know that it is a 50-lb. piece. It must be sharp cornered and regular, and if you cannot produce that by using distilled water, then use raw water, but if you can produce it by means of making distilled water can ice, and do it just as economically, then you had better use the distilled water. In the raw water process, both plate and can, the circulation of air has often given trouble by freezing at the orifices of the air pipes. We all know that when air expands, even if it is idle expansion directly into the atmosphere, from any pressure above the atmosphere, a production of cold takes place at the orifice, from which the air oozes into the atmosphere. In blowing air into water, the air has to perform work, it has to push the water aside, and the result is that a low temperature is caused. All sorts of expedients have been resorted to for the purpose of

preventing this freezing of the air nozzles in plate plants and can plants. The air has been dried, as it has been thought that the moisture in the air would produce this freezing, but the real cause has never been discovered. In my judgment it is a simple matter to prevent the freezing of the air at the opening by shaping the nozzles in such a manner that the orifice is enlarged; in other words, have the orifice trumpet shaped, tulip shaped, so that if the air pipe is an eighth of an inch, the orifice through which the air oozes into the water is half an inch or five-eighth of an inch large, and then you will find that even in six days no freezing at the orifice will take place. I am often asked, "What would you recommend—a plate plant or a can plant?" And I simply ask the intending purchaser, "What have you been accustomed to in your town?" If he says, "can ice," then I say, "put in a can plant." If he says, "natural ice," I say, "put in a plate plant." I think that is the way it will be all through the country. It has been so. In the South, plate plants could not be built, or they have been built and abandoned. In our part of the country, people want can ice as well as in the South, while further North and East, they want plate ice and therefore plate plants have been built.

H. D. Pownall.—I would like to answer Mr. Block. He has questioned the economy of electric operation, saying that no one can afford to purchase electricity for operating ice making plants. I say they can, and believe I can prove my statement. Furthermore, I believe that the average ice manufacturer does not thoroughly investigate and very few know exactly what their ice costs them. As to what a manufacturer can afford to pay for electricity, this depends entirely upon several matters; the initial cost of plant, cost of real estate, interest on the investment, insurance, taxes, depreciation, and the cost of labor to operate the plant, as compared with the cost of a steam driven, or other type of plant to produce the same result. In many cases it can be shown where it is economy to pay from 50 cents to 60 cents per ton for electric power as against 20 cents per ton for power when using compound condensing engine, producer gas engine or oil engine. This being due to the fact that the total cost of prodcing a given amount of ice, even though the power cost is 2½ to 3 times as great, may be less than that of the plant using the lower priced power. These questions must be figured either by the customer or his consulting

engineer must calculate them for him. I believe I can demonstrate that in New York City a man can afford to pay ⅛ cent per kilowatt or more for power and produce ice for less than he can with any type of steam driven plant.

Louis Block.—He may be able to pay ⅛ cent per kilowatt for electricity, but he cannot buy it at that price.

H. D. Pownall.—Yes, he can buy it at that figure.

Louis Block.—No, he cannot.

H. D. Pownall.—I will say to you that I can get power for any customer of yours who wants to put in a plant in Greater New York for ⅛ cent.

Louis Block.—I wish you would put that in writing, as the best I can do is 2¼ cents.

H. D. Pownall.—I can do it. Whatever I claim, I can do. The Edison Electric Illuminating Company of Brooklyn are furnishing power to the Bay Ridge Ice Manufacturing Company at that price.

Louis Block.—And what besides?

H. D. Pownall.—There is absolutely no other charge. For every ton of ice produced there is a charge of ⅛ cent per kilowatt for each kilowatt that goes through their meter.

John C. Sparks.—Isn't that a special rate though?

H. D. Pownall.—You might call it a special rate. It is a rate based on operating a certain number of days per year at full capacity.

John C. Sparks.—At a certain time each day?

H. D. Pownall.—No, sir. Twenty-four hours per day during June, July, August and September, running the plant at full capacity. They further have the same rate on operating the plant for another four months, April, May, October and November, and then for the other months of the year they agree to keep off the line from four P. M. until eight P. M. Now, is there an ice plant in the United States that cannot keep off of the line from four until eight P. M. during December, January, February and March? If there is, I would like to know where it is located?

John C. Sparks.—In your contract have you the words, "Merchantable ice?"

H. D. Pownall.—If it is not there, the Arctic Ice Machine Company will certainly produce the goods.

John C. Sparks.—Do you expect to make merchantable ice at Bay Ridge?

H. D. Pownall.—Yes, sir, absolutely.

John C. Sparks.—I wish you luck.

H. D. Pownall.—Now, if there is any question about my statement regarding the cost of electricity in Brooklyn, the sales engineer of the Edison Company in Brooklyn, will be at this meeting either this afternoon or tomorrow—Mr. Stevens. If there is any question of doubt regarding the quality of ice, come down to the exhibition tonight and I will show you better ice than you ever saw before.

John C. Sparks.—Made with Bay Ridge water?

H. D. Pownall.—Not made with Bay Ridge water, but just water. Now I will say to you further, gentlemen, I am willing to make this absolute guarantee; I will guarantee raw water ice made in cans by our system to show less bacterial content than any block of distilled water ice made in the United States today. Now, that is a pretty broad statement, I challenge anybody to disprove it.

John C. Sparks.—Don't you care what the original water is?

H. D. Pownall.—I care nothing about the original water, if you will allow me to treat it in my own way.

John C. Sparks.—For instance, if it was Croton water with very few bacteria, or water from Coatesville with a very large bacterial content, that wouldn't make any difference?

H. D. Pownall.—It don't make any difference whatever if put through the filtering process and properly treated.

Hugh Hamilton.—I want to know whether raw water ice will stand knocking about in the delivery wagon the same as distilled water ice?

H. D. Pownall.—I don't know whether that question was addressed to me or not. I am not an ice retailer, but I will say that, if the raw water ice goes into a storage room and is allowed to temper the same as other ice, it will stand the same usage as the distilled water block and it will cut just as well; you can cut high-ball cubes out of it with a pick, and if you can do that, you can do anything with it.

Hugh Hamilton.—My objection to raw water ice is that it will not stand delivery in the wagon; distilled water ice is not as easily broken and will stand better than raw water ice, particularly in the Southern country; it may not be the same in the East.

John C. Sparks.—That is the only point Mr. Pownall and I agree on. May I ask you what temperature your brine was carried at?

Hugh Hamilton.—Twenty-eight. I have frozen it at 16 and it wouldn't stand.

John C. Sparks.—The lower the temperature, the less it will stand.

H. D. Pownall.—I am glad to know that Mr. Sparks agrees with me on something; I think he will agree with me on everything before the expiration of ten years. In an ordinary block of raw water ice, where the core water is not removed, you have all of the salts of magnesia, lime and other impurities, that were originally in the 300 pounds of water, concentrated in from three to five pounds of water which constitute the core, and anything that has the word "salt" connected with it has a lower freezing temperature than pure water, consequently, that block of ice will become mushy through the center and deteriorate if allowed to stand, or it will break more easily than a block that has no salts in it, because of the fact that when it is exposed to a temperature above freezing, the salts, etc., in the center of the block immediately begin to melt and cause a mushy condition in the center of the block, while the clear portion is just as good as any distilled water ice. That, I think, explains your trouble.

John C. Sparks.—Have you ever put a thermometer in the core, just before it froze up, to see what the temperature was? I was at a plant in Brooklyn, which is going to be a cousin of your plant, and the temperature was 26 in the water in the core of that raw water can ice. The water contained about 60 grains of sodium chloride and about 100 grains of sulphate of magnesium per gallon and the ice was very poor.

Hugh Hamilton.—About seven years ago I put in a block plant, built by the Vilter Manufacturing Company. The ice was beautiful, clear as the finest plate glass you ever saw, and the machine did very well. It was not any more economical than the distilled water plant, but I thought I would get around the bad odor and bad taste in the ice. A great many men and women also want a pitcher of ice water in the room at night; they will wake up and want to take a drink, and if it is distilled water ice, the water tastes bad. I thought I would advertise the block ice. The wagons took the ice out, but it would break all to pieces after

they hauled it eight or ten blocks. Well, I had some cans made, six hundred pound cans, as it took six hundred pound cans to fit in the tank. I used the air the same as the gentleman spoke of. The ice was clear, looked fine, but the drivers could not sell it against the distilled water ice, because distilled water ice looked better and did not break, and, gentlemen, when you go into the country or into a place where they have been using distilled water ice for years and don't know anything about anything else, you will have trouble to introduce the raw water ice. Now, I have been in the ice business for some time, I have been in it since 1877, done nothing else, and I know something about it. I have experimented a good deal in freezing ice, because I have been wanting to do away with distilled water ice. You only have half the bother with the three hundred pound can that you do with the six hundred pound can.

H. D. Pownall.—Mr. Sparks raised the point a few minutes ago regarding the temperature of the water in the core, and where there are certain salts to contend with in the water. That is a matter in which I have had some experience. The Arctic Ice Machine Company received a sample of water from Roswell, New Mexico, with a request that we freeze this sample and see what kind of block we could produce. When the block of ice weighing about three hundred pounds was frozen so that there was probably thirty pounds of water remaining in the core, or one-tenth of the original contents, the temperature of the brine in tank had reached about 6 degrees below zero, and we operated for twenty-four hours with this temperature and could not freeze the block of ice solid, showing conclusively that we had concentrated all the salts out of the water into a solution that was practically a strong brine. That is what we get rid of by withdrawing the core from the block and refilling with fresh water, which will freeze at 32° F.

John C. Sparks.—Are you sure that a large part of your mineral salts go into the center of your can as well as most of the other impurities? How can you make the guarantee that there would be no bacteria? Do they go into the center of the can?

H. D. Pownall.—I might state I believe that bacteria are just exactly like a drowning man in the middle of the ocean—grab at a straw. Bacteria do not exist where there are no impurities and

bacteria will cling to the impurities absolutely, whether the chemist says so or not. Now, I want to say to you this, that when we put into operation a raw water plant in a certain town not located more than five hundred miles from Chicago, certain of the people who were manufacturing distilled water ice threatened to take the matter up with the Board of Health and prevent the sale of raw water ice. Immediately on being informed of this, I secured the services of two of the leading chemists of that city and had them secure a block of raw water ice and also seven other blocks of distilled water ice made by the various concerns in the city. According to their analysis the core from the raw water ice, refilled with distilled water, showed 6 bacteria per cubic centimeter, while the core from the distilled water ice showed an average of 160,000 bacteria per cubic centimeter from the seven blocks. We have the analyses of Long & Brucker, two of the most prominent chemists in the country, which are open to anybody for inspection.

John C. Sparks.—You can get any kind of figure you like. I have brought this subject up often before. It is quite likely that you can get a high count of bacteria in distilled water can ice, but there you were making a comparison between one distilled water core and another distilled water core; you were not making any comparison between two types of ice making, and, according to your own statement, you took one of yours and seven of theirs, when really, to find out the difference, you should have followed their distilled water from the point where it came from to the can-filler, the cans, the core and in different parts of the freezing tank. You cannot condemn an ice tank because one part of the tank does not produce especially clean ice, nor can you commend your process because one cake produced your low figure. I do not think that was any comparison at all.

L. C. Nordmeyer.—I want to ask Mr. Pownall if those bacteria found in the water were friendly or unfriendly?

H. D. Pownall.—I can answer Mr. Nordmeyer pretty quick, I will say they were all friendly. But as differing with Mr. Sparks, I can only say this, that in freezing raw water ice, in cans with air agitation, the bacteria are thrown off with the impurities and are concentrated in the core. Now, if we withdraw the core water through the bottom of the can, and then refill the center of the block with distilled or fresh raw water, about ten pounds of water being required for each can, we need not consider whether it

is distilled or raw water ice, we have eliminated the impurities to begin with and we have refilled with fresh water. Now it requires from an hour and a half to two hours to freeze the ten pounds of water remaining in the center of the block, whereas in comparison a 300-pound distilled water block with ordinary circulation at a temperature of 12 degrees it will take from 40 to 44 hours to freeze, consequently, if there are a certain amount of bacteria in that water to begin with, they have from 40 to 44 hours to multiply before the final conclusion of the freeze; whereas, with the raw water proposition, the bacteria have only one and a half to two hours in which to multiply and consequently there will not be as many.

John C. Sparks.—In the first place, bacteria do not multiply at that temperature in water. In the second place, if you start with a water high in bacteria, they are pushed to the center. It is a question of degree as compared with the original water; they run from an infinite number to zero, and therefore it is just a question of comparison. Exactly the same thing goes on when you refill your core; whatever was in the water when you refill it is again, in a degree, pushed toward the center; you don't get rid of them.

Thomas Shipley.—My experience is that the demand for raw water ice comes from the alleged economy of such plants; and my opinion is the result of inquiries for plants all over this country. Now, as to the fuel economy, I have a memorandum here of plants which our company has designed and put in operation where we get the following fuel economy. At one plant they run 26 to 30 tons of ice per ton of coal; at another plant 26; another plant 24 tons of ice per ton of coal; another plant 30 tons of ice per ton of coal. Well now, gentlemen, that's a fact, they do produce that much raw water ice per ton of coal with gas producer and a gas engine. Three of these plants use 1,200-pound cans and we don't have the multiplicity of troubles with them that Mr. Sparks believes we should have. We have a lot more trouble with 300-pound cans, almost in proportion to the weight, because we have four vessels to freeze and four cores to pump out as against one core with the 1,200-pound block. We must saw these 1,200-pound blocks into 300-pound pieces. This, of course, takes some work and some additional power, but the ice is free of the central core. This, however, is not as much of an advantage as some advocates of the

1,200-pound can claim, but it serves as a talking point in selling the ice. In fact, it is a question in my mind which size can is the best. I believe it depends much upon what the trade demands My opinion of this whole question, based upon my own knowledge and upon the information I gather through the organization with which I am connected, is that if we could produce distilled water ice at or near the fuel economy of raw water plants, such plants would soon go out of fashion.

As to the possibility of our obtaining such fuel economy, I wish to call to your attention some of the things I have learned at the Refrigeration Congress. In talking to some of the foreign delegates I find that in Europe there are many plants which are producing 22 tons of distilled water ice per ton of coal. The designers of these plants have gone in for refinements in steam economy we have not as yet attempted in this country. The plants I refer to are steam plants, not gas engines or oil engine plants. When we wake up to the possibility of such plants, we are certain to discard the many freak designs now being advocated among us.

Distilled water ice plants require less labor to operate and have less troubles than do raw water plants, which require air circulating systems, pump-out systems, re-filling systems, etc., etc., with all their attending troubles and costly up-keep. Hence, the plant that gives us the fuel economy without these troubles will be the one of which we will sell the most.

If we take proper precautions to keep bacteria out of our distilled water after we have made it, there should be no question but that the ice produced from such water will be pure, provided we keep our tank tops clean and not allow dirty water, which we use to thaw the ice from the cans, to get into the cans when they are being dumped. I have seen cans immersed into the dirty water in the dip tanks so that they were washed inside as well as outside with the dirtiest water about the place. And not only that, when the cans were put back into the tank to be filled, there remained at least one pint of this filthy water within them. With this kind of treatment, what is the use of attempting to make pure ice. This is a matter we will soon have forced to our attention by the health authorities.

It is my opinion that the day is not far distant when we will have on our markets distilled water plants which will produce at least

twenty tons of ice per ton of coal. Then the raw water plants will not have so much of a call as they have to-day.

Mr. Sparks is perfectly right about the necessity of cleanliness about ice plants and he has called this matter to our attention time and time again, explaining that the principal cause of the bacteria in can ice comes from the fact that we do not keep our plants clean. We tramp around on the top of the tanks, tracking brine and filth all over the top of the can covers, where it seeps down through the rotten, dirty can covers, that never get cleaned, into the water that we have tried to purify, and, of course, the bacteria is there by the million—couldn't be anything else—and then the poor ice machine man gets it in the neck. He is called on to come around and kill all the bacteria. It is not his job at all; the tank man ought to keep the tank clean and the engineer should insist upon it being done. Many times we do not care to antagonize the engineers of the plant by speaking our mind about these matters. It is a hard matter to avoid kicking up a row when we find that the filter system, with which we have equipped the plant, has been allowed to become a cesspool from neglect. Many such plants show no bacteria in the water before the filters, but millions of them are in the same water after it has passed through the filth contained in the filters. Some engineers believe a filter should run a season without requiring cleaning and they and many owners get angry when told that this is not a fact.

H. D. Pownall.—I have talked a great deal here but I would dislike to let Mr. Shipley's remarks go unanswered. Mr. Shipley makes the statement that, with the raw water plant, he does not get away from the trouble of freezing up the air pipes, etc. In the system to which I referred there are no nozzles to freeze, and consequently we do not have that trouble to contend with. Mr. Shipley has mentioned making 22, 28, and 30 tons of ice per ton of coal. This can be accomplished with the distilled water systems only by means of a multiple-effect evaporating system, and this materially adds to the initial cost of the plant and requires far more attention to keep the plant in satisfactory operation. It simply resolves itself down to the first remarks I made—it's a question of what the initial cost of the plant is as compared with the number of tons of ice you make per year and the cost to manufacture the ice at the end of the year, taking it from the first day of January to the first day of January. There are many instances in which we can

afford to install a slide valve engine and make three and a half tons of ice per ton of coal rather than advise a Corliss engine or a Lentz engine and make fifteen or twenty tons of ice per ton of coal. It is merely a matter of local conditions and the amount of ice you can sell.

Thomas Shipley.—I don't believe in letting Mr. Pownall get away with the kick on evaporators; for he has more pipes to each can than there would be to a dozen evaporators. A man who can be satisfied with a plant having three pipe connections to the bottom of each 300-pound can has no kick coming against an evaporator.

John C. Sparks.—Mr. Shipley! Do you increase the amount of air in proportion to the increased size of your cans?

Thomas Shipley.—We haven't that matter down fine enough to say just what we do require. We worry with it until we get good ice.

John C. Sparks.—But, as a matter of fact, do you?

Thomas Shipley.—Why, as a matter of fact, we put in larger connections and naturally use more air with the 1,200-pound cans.

John C. Sparks.—A great many people don't put in the extra connections.

Thomas Shipley.—We do very well after we purify the water. but the trouble we have is with the samples of water, sent to us to analyze. The sample sent us may represent the water at the time it is taken, but it does not represent the different kinds of water the plant will be called upon to use during the season, for the reason that most water supplies are subject to many changes during the year, owing to the droughts and freshets which they are subjected to, hence the only safe thing to do is to insist upon a water purifying plant being put in on every raw water plant, and my instruction to our men is, "In all raw water ice contracts include a purifying apparatus."

John C. Sparks.—Do you specify merchantable ice or how do you work it? There is a great deal of difficulty in that.

Thomas Shipley.—We insist on the purchaser guaranteeing the water supply. If the trouble is in the water, then he must remedy it. With this understanding we guarantee merchantable ice

John C. Sparks.—What do you say? Do you use the word "Suitable?" You have got to put the responsibility on someone.

Thomas Shipley.—I say if the water is not suitable for making ice, the customer must furnish a purifying apparatus.

John C. Sparks.—Do you withdraw the core?

Thomas Shipley.—Yes, sir, about thirty pounds, and put in raw water.

John C. Sparks.—When you sell those plants, do you put in those connections for drawing out the core? Sometimes the question of withdrawing the core has been an afterthought.

Thomas Shipley.—We always furnish the connection. If they don't need it, they don't use it, and if they do need it it is there.

John C. Sparks.—I think that one of the things that has given raw water ice a bad name is that the manufacturer adds a lot of things afterwards.

Thomas Shipley.—Yes, we had a complaint from a plant we put in not long ago, that we sent them too much material. We had sent them connections for every can, both for circulating the air and for taking out the core water, and they kicked up a row because we furnished so many connections. However, when it was properly explained, they stopped kicking.

The contentions of the purchaser and his engineer were that there was so many connections about that they couldn't walk around on the tank. This was because no proper provision had been made to hang up the parts not being used. After this was done, the trouble ceased so far as the complaint went. There is no question but that a raw water plant requires a great many connections which are confusing and annoying to tank men, especially those who have been used to distilled water plants, and it is my hope that with the aid of the evaporator men we will soon get distilled water plants down to their proper place. This will require the exercise of our engineering skill to a somewhat finer degree than heretofore, but it must come.

John C. Sparks.—Mr. Shipley, I am glad to see that you feel more kindly toward evaporators than you used to.

L. C. Nordmeyer.—I would like to ask why operators of distilled water plants insist on making distilled water ice when they cannot make it as economical as in raw water plants, or any better?

Thomas Shipley.—I said I had been talking to a foreign delegate who said, "In Germany they are making 22 tons of ice per ton of coal." Unless we are going to admit that we cannot do as

well as they, why should we be willing to put up plants that only make 15, 16 and 18 tons of ice per ton of coal, I gave you the figures as to what is being done by gas producer plants that we have put up, making raw water ice, that is, from 25 to 30 tons of ice per ton of coal, but if we can produce, say 20 or 22 tons of distilled water ice per ton of coal the difference in fuel economy will not justify the troubles we have with raw water plants, unless we must use electric power, gas or oil engine installations.

L. C. Nordmeyer.—Can you make the distilled water ice that you speak of, Mr. Shipley, as cheaply, considering the entire cost of the plant, including depreciations, as they do with the present raw water plants?

Thomas Shipley.—I do not think there will be much difference in cost.

M. R. Carpenter.—There is one point that has not been touched upon in connection with the raw water plant and air circulating system, and that is the purification of the air circulated through this water.

John C. Sparks.—Air and water-born bacteria are entirely different.

M. R. Carpenter.—I have heard it said that consumption is transferred through the air and that it is possible to get many diseases through the air. In examining an air pipe that had been used for about a year, I found the whole inside of it encrusted with a sort of slime. The air pipe had been partially plugged up. I do not know whether that slime was the result of oil coming through from the blower, or whether it was the result of impurities in the air coming through and clogging when they got pretty near to the cold air tank—wouldn't go any further and stayed there; but it was like the slime that is left after something has been submerged in water, and I believe there are more or less bacteria in the air that are transferred into the water.

John C. Sparks.—That was algae, either anabanae or crenothrix. That is entirely different; you don't consider algae when you talk about bacteria; it was not bacteria.

M. R. Carpenter.—We had algae in the water at Cincinnati and the city has gone to considerable expense to filter that water and treat it with chemicals.

R. H. Tait.—We will assume that they can both make good ice, the distilled water and raw water men. I think the determin-

ing points in the selection of a plant by the owner are found entirely in the location and conditions. It does not always pay to refine a plant. It does not pay to put on 10 cents per ton in construction and depreciation and take off 5 cents per ton in fuel. I think the determining factor in the selection of a plant by a man who is going to build a plant is a good deal like whether he shall buy a hay wagon or a buggy; it depends entirely on how he is going to use it and under what conditions. He must take all the conditions into consideration before he determines on the type of plant to be used. If water is cold and fuel is cheap, he cannot afford to refine a plant. We have had under consideration many plants where the question was, what kind of plant to install? Where we could not advise anything more refined than the old style can plant. So I think the proper selection depends entirely on the conditions and the intelligent view he takes before going into it.

Louis Block.—Still, if the ordinary can plant will make 3½ tons of ice, say, with a ton of coal and you could double that without extra expense, you would do it?

R. H. Tait.—Without extra expense—yes.

Louis Block.—Well, with very slight expense, but still the interest on the extra capital invested would not amount to enough to increase the cost of production 10 cents per ton, while you could make 3½ tons more of ice per ton of coal and hereby save, say, 20 cents per ton—it will then surely pay you to put it on.

R. H. Tait.—That is axiomatic; if you can save money by putting in a refined plant, that is the thing to do, but it does not always hold, and the average plant owner or prospective plant owner is always capable of determining that, neither can he depend on the man who is selling apparatus to him, because a good salesman is going to sell the apparatus he has to sell, giving to him the best he has to suit the conditions.

Louis Block.—I especially bring this up in connection with the statement made by Mr. Shipley, that in Germany they are making 22 tons of ice per ton of coal. It was, I suppose, the same gentleman who made that statement to me on the steamer coming over. I have seen steam economics that opened my eyes, ordinarily apparatus, once put in it needs no further attention.

W. J. May.—Another matter which should be taken up at the present time is the coal cost. In the ordinary plant to-day this charge averages 50 cents to $1.00 a ton of ice. In New York

the power cost with the electric drive will be not more than 50 cents per ton. Now, in our ordinary plant, where our fuel consumption is $1.00 a ton or near it, we have a very expensive apparatus to take care of in our steam driven engine and machinery, the ordinary repairs on which amount to two or three times those on a motor driven machine; we have also our filters to take care of. Still the greatest fault and trouble in all plants is the boiler proposition and, when it comes to cleaning boilers, it is an expensive job. Now, will it pay us to install a raw water motor-driven plant, even if we have to spend 60 to 75 cents a ton for power as against a compound-condensing aparatus with evaporator and filters? That is a question I would like to have answered. If you compare a motor-driven raw water plant, in first cost, with a compound-condensing apparatus and evaporators, which will pay the best on the investment?

Van R. H. Greene.—I don't believe that I can add much to the discussion that has already been given. The only thing that occurs to me is in the comparison of the work we have done in this country and the work that has been done abroad. They have made much more ice per ton of coal abroad than we have done here, but the reason is quite plain. There the fuel cost is excessively high and the labor cost required to produce these refinements is quite low. Here in this country where the reverse condition exists, it is difficult to induce people to consider a very high grade plant, because it takes so long to pay for itself. I was just thinking of what Mr. Tait said and wondering how many years it would take the savings made by the condensing plant to pay for the increased first cost.

R. H. Tait.—I would not figure that it had to run over any term of years at all; depreciation, taxes, repairs, increased cost of the plant, take all these costs and charge them per ton of ice produced. You will find the cost of fuel is about the only cost that goes down as the cost of everything else runs up, and it does not pay to put more cost on as depreciation and investment than is taken off the coal; the thing will strike its own balance; it does not need to be considered for any term of years.

Van R. H. Greene.—That is very true, but the first question people will ask us is, "How long will it take for the plant to pay for itself?" And if it runs over six years, they won't listen to you.

R. H. Tait.—If the refined plant costs more by .1 cent per ton, it will never pay for itself.

Van R. H. Greene.—I have known people to say to whom it has been shown that the plant would pay for itself—an oil engine driven plant—in six years. "No, we don't want that."

R. H. Tait.—That very point is covered, I think, by the tabulation in Mr. Nordmeyer's paper that was read before the Refrigeration Congress this morning.

L. C. Nordmeyer.—The data in this paper is based on a plant where the production of ice was figured with July running maximum capacity, July being 15 per cent. of the total output of the year. This means that a plant of 100 tons daily capacity could produce, if operated 365 days in the year, 36,500 tons. Then this 15 per cent. that we use for July would give the total output of this plant as 57 per cent. of 36,500 tons. The figures of capacity in this paper do not show exactly the same comparison, as we based them on 72 tons. The cost of the buildings was the same and included in addition to the power plant building a complete cold storage house. The types of plants considered were a simple steam plant, a compound-condensing steam plant and an oil engine driven plant. The cost of machinery in the simple steam plant was $65,000; the cost of machinery in the compound-condensing steam plant was $76,400, and in the oil-engine driven plant was $83,923.

The comparative cost of installation and operation of the three types of plants is given in the following table:

	Simple Steam Plant	Compound Condensing Steam Plant	Diesel Engine Plant
Cost buildings	$60,000.00	$60,000.00	$60,000.00
Cost machinery	65,000.00	76,400.00	83,923.00
Total cost	125,000.00	136,400.00	143,923.00
Cost water per ton ice	.....	.....	$0.09
Cost fuel per ton ice	$0.976	$0.753	.226
Fixed charges machinery	.546	.642	.821
Operating cost	.579	.579	.516
Cost per ton ice	2.101	1.974	1.653
Building charge per ton ice	.504	.504	.504
Cost per ton ice	$2.605	$2.478	$2.457

From the above table the following comparisons can be deducted:

Simple Steam Plant vs. Compound Condensing Plant: The compound condensing steam plant costs $11,400.00 more than the simple steam plant, but a saving of 12.7 cents per ton of ice is accomplished, which for 14,880 tons of ice-making capacity per year amount to $1,889.76 per year. On this basis the compound condensing steam plant will pay for the difference in cost between it and the simple plant in approximately 6 years.

Simple Steam Plant vs. Diesel Engine Plant: The Diesel engine plant will cost $18,923.00 more than the simple steam plant, but a saving is accomplished of 44.8 cents per ton of ice, or $6,666.24 per year. On this basis the Diesel engine plant will pay for the difference in cost between it and the simple steam plant in less than three years.

Compound Condensing Plant vs. Diesel Engine Plant: The Diesel engine plant costs $7,523.00 more than the compound condensing steam plant, but a saving of 32.1 cents per ton of ice is accomplished, which amounts to $4,776.50 per year. From this you will note that the Diesel engine plant will pay for the difference in cost between it and the compound condensing steam plant in less than two years' time.

Finally: From the comparison given above, it seems apparent that the oil engine plant would be an exceedingly good investment. This should especially be apparent on account of the manner in which the deductions were made. The steam-driven plants were given the benefit of the best efficiency that could be obtained—namely, a boiler efficiency in the case of the simple plant of 65 per cent.; and in the case of the compound condensing steam plant, with the use of an economizer, of 71½ per cent.

The steam consumption of the simple engine of the refrigerating machine was assumed to be 27 lbs. per IHP. hr., while that of the electrical generators was assumed to be 30 lbs. of steam per IHP. hr.

In the case of the compound condensing steam plant, a steam consumption of 18 lbs. per IHP. hr. for the steam engines of the refrigerating machine and 20 lbs. per IHP. hr. for the generator engines was assumed, including the steam for vacuum pumps and other auxiliaries.

In the oil engine plant, the engines were credited with a low efficiency of 8-gal. per hundred BHP. hrs., while we have found that the fuel consumption of engines installed in the southwest by the Busch-Sulzer Bros. Diesel Engine Co. was approximately 6½ gals. per hundred BHP. hours under normal working conditions. In addition to this, the oil engine plant is charged with water bought from the city, as against artesian well water used in the steam plant.

A further advantage is given the steam installation, by charging them with a depreciation and obsolescence of only 5 per cent. as against 10 per cent. charged to the Diesel oil engine installation.

The present prices of fuel oil will somewhat change the figures as shown, but cannot help but prove the oil engine a good investment.

Thomas Shipley.—Was that a gas engine plant?

L. C. Nordmeyer.—It was an oil engine plant.

D. S. Jacobus.—There is one phase of this problem that has not been touched on, which is the idea of combining an electrical generating plant and an ice making plant. In an electrical generating plant there is usually a low load period during the day and by operating an ice making machine during the low load period ice could be produced as a by-product at a less cost than it could be in a plant employed solely for ice making. Furthermore, the condensed steam from the steam turbines could be used for the ice and in this way as high figures for ice made per pound of coal could be obtained with distilled water as with water that is not distilled.

Thomas Shipley.—I think that we ought to emphasize the fact that this paper of Mr. Nordmeyer and Mr. Tait is based on oil fuel only and not for coal. I guess a few of us will take a chance at making ice at less than 97 cents a ton for fuel, using coal. Mr. Nordmeyer pulls that on us and tries to down the distilled water ice. I think we can beat the life out of that cost.

L. C. Nordmeyer.—I venture to say that Mr. Shipley will not be able to find the price for fuel per ton of ice go much below 90 cents in the territory this paper particularly covered. They pay for fuel down there $3.00 to $4.00 a ton for bituminous coal, and $1.85 to $2.00 and more for lignite coal.

John C. Sparks.—Where is down there?

L. C. Nordmeyer.—Southwestern Texas.

W. E. Parsons.—I have heard what has already been said, and it has been very interesting to me, and I think the subject has been pretty well thrashed out. Dr. Jacobus mentioned something a while ago regarding the combination of electric plants and ice making plants, and that suggested to me that I might be permitted to say a word about a process in which, with others, I am interested, and with which we have already made some progress in connection with electric lighting plants. We have a quick freeze process and are able to freeze 300-pound blocks completely in the offpeak period and harvest the ice during the peak period. In regard to distilled water ice, or raw water ice, we can use either process with our system of freezing.

A. I. Stahl.—Speaking of electrically driven machinery and the cost of making ice prompts me to suggest that a process is used now in South Bend, Ind., that was invented by John Patten, of Baltimore, and various plants built during the past 12 years, which, through mismanagement, went to the junk pile, but the plant at South Bend is being operated by electricity and is commercially successful. They make ice with the vacuum system, spraying raw water into a high vacuum. A portion of the water breaks into vapor, and in so doing carries with it the heat from the remaining water, reducing that to a temperature below freezing. The water is introduced through a spray head, with numerous nozzles, which is revolved and moved up and down so that a second portion of water will not strike immediately upon the same surface. The stream, in passing from the nozzle to the shell, which is three feet distant from the nozzle, loses a portion which passes into vapor, chilling the remainder to the point below freezing, but as the stream is in motion it does not congeal until it strikes the surface of the shell against which it is sprayed, when it does immediately congeal, forming a thin film of ice. The spray-head, revolving and moving up and down, deposits repeated layers or films of ice until a wall two feet thick is built up, like layers of paper one against the other. When the meter through which the water has passed indicates sufficient quantity to make a cylinder or cake weighing three tons, the water is shut off and the vacuum is broken by the admission of air. Some steam is then admitted to warm the shell, so that it will let loose from the wall of ice and the ice on the bottom of the freezer. The bottom of the freezer is the top of a hydraulic elevator and is lowered, and the block of ice, eight feet in diameter,

three and a half feet high, two feet thick all around. resembling a big baked apple with a four-foot core, is before you. A block of ice resembles Cararra marble. The globules, as they congeal, become opaque; while they are clear they do not form crystals, and therefore the ice is opaque, resembling a block of white marble.

A saw operated by a motor on an arm is thrown forward, cutting a slit, pointed toward the center. A hydraulic ram moves the bottom one-twentieth of a turn; the saw comes forward and cuts another slit. The block between the two slits, weighing three hundred and odd pounds, is pulled out and slid into the storage room.

The large volume of vapor generated must be taken care of. The freezing, I will explain, takes place only when the vacuum is up to 29½ inches—within a half inch of absolute—difficult to obtain—no other known mechanical process uses so high a vacuum as is required to make ice in a vacuum. At 29 inches of vacuum, snow forms; at 29¼ inches, soft ice; at 29½ inches the ice is firm and solid. Vacuum ice is a little more dense than that made in any other way, 30⅛ cubic inches weighing a pound, according to the computation made by a man, whose name I heard spoken a moment ago, Dr. Jacobus; while with other ice 31¼ to 32 cubic inches make a pound. The vacuum takes with it the air and gases which are in the raw water, the same as boiling would do. It also obliterates life in all bacteria that might be present in the water. Tests by a chemist in Baltimore showed 88 colonies of bacteria in the water taken from the city hydrant which was filtered and then used in spraying into the freezer. Water from melted ice developed, according to his report, one colony. A second test by him showed one colony, and his statement is that "they must have been accidental, from the atmosphere, and not present in the ice."

The large volumes of vapor, air and gas could not be handled with a vacuum pump and a method of eliminating the large volumes had to be found. Water multiplies three thousand times in changing from liquid to vapor in the high vacuum. You can, from that, know the very large volume of vapor that is passing out, for one-sixth of the water sprayed into the freezer breaks into vapor. By having a large chamber filled with coils of lead pipe, the coils externally coated or bathed with sulphuric acid, through which water is circulated to carry away the heat the vapor brought from

the water that remains, and heat generated by mingling sulphuric acid and water, causes the vapor, as it passes through, to be absorbed, condensed, its volume changed from three thousand back to one, and the air pump, the vacuum pump, only has to handle the air and gases. The quantity of coils and the amount of surface for the acid to cover controls the rapidity with which the water can be sprayed into the freezing chamber.

The acid, after taking up this water, condensed vapor, is diluted and cannot be used over again. It passes down into a well, deep enough below the absorber chamber so that the vacuum does not lift it back. From there it is pumped into concentrator pans and the water boiled out of it. It is then ready to be used over again through the absorber, and the process is to use the acid through that cycle—down through the absorber into the well, pumped up into the concentrator and from that through cooling coils over to the absorber again.

An economy is to pass this cool acid, tests showing 80 degrees in the well, through the hot acid, transferring heat from the hot acid to the cool, thus reducing the hot acid, which must be reduced to a temperature of perhaps 70 degrees before using it in the absorber. An exchange of 100 degrees from the heated acid to the cool acid raises it, from 80 degrees out of the well, to 180 degrees when it passes into the concentrator pan, saving that much steam. The acid out of the concentrator pan at 240 or 250 degrees will be reduced by that 100 degrees, thus saving the quantity of water through the coils to take up that 100 degrees.

Steam in coils within the concentrator pans is used to raise the temperature above the boiling point of water in acid and drive the water out of the acid. Therefore, it is necessary to have a steam plant. The machinery connected with a vacuum plant is operated by electric motors. Instead of buying power from the electric company it is cheaper to take the steam from the boiler through the engine, generate the current needed for power, then pass the exhaust steam into the coils. The power obtained in that way is costing very little. Necessarily some live steam is used in order to raise the acid to so high a temperature as 250 degrees. The amount of heat needed to raise the temperature of the acid to the point where it will be concentrated—the heat necessary to volatilize or to vaporize the water in the acid—is the amount of heat needed, and, as I compute it, by adding 50 per cent. to the B.t.u.

actually used for that purpose, this 50 per cent. to cover radiation from the concentrator pan, radiation from the pipe line from boiler to engine and from the boiler to the concentrator and for thawing the ice loose from the freezer, I have covered all heat required. With coal at $2.50 per ton this averages the cost at 10¼ cents per ton of ice made. That 10¼ cents will cover the cost of the power to drive the machinery and concentrate the acid.

The machinery used are the vacuum pumps—two of them, one exhausting into the other so as to avoid the high duty pump exhausting against the atmosphere direct—an air compressor for lifting the acid from the well to the pan; a pump for circulating the water through the coils and into the freezer; and you see from this there is but little machinery—a 30 H.P. motor being large enough to handle an output of 75 tons of ice per day.

The plant now in operation at South Bend has a capacity of 30 tons per day. Owing to an inefficient concentrator delaying the freeze they are making but six freezes, of three tons each, in twenty-four hours. One man fires the boiler, operates the machinery and harvests the ice in the day time, another one at night—labor cost very low. We figure the depreciation at 15 cents per ton; taxes, insurance and incidentals, 4 cents per ton; coal at 10¼ cents per ton; labor at 17¾ cents per ton, and we have the total cost per ton of ice, on an output of 30,000 tons per annum, as 47 cents. We say to ourselves that we are sure we can put vacuum ice into the wagons at 60 cents per ton.

W. E. Parsons.—Do you know whether the vacuum plant in Baltimore is still operating by the same process?

A. J. Stahl.—The plant in Baltimore went on the rocks financially. It was sold under the hammer; as I understand it, it was bought and scrapped. There is a plant in a town 17 miles from Baltimore, which I never saw, that I understand is in operation and has been for six years.

W. E. Parsons.—There was one in New York City.

A. J. Stahl.—The one in New York City was built on borrowed money. I received a circular from Mr. Patten that contained a cut of the New York City plant and I immediately wrote him for information about it and he replied to me in a way that was entirely satisfactory; it was built on borrowed money, managed by men other than himself, who knew little about the operation, and there was trouble. He was put in charge and had a corps of men

under him that were making ice and distributing it through the city, and, from testimonials published in the circular he sent me, many people thought well of his ice. Later on he was displaced and another man put in charge who immediately changed the personel of working men. Failure was the result, and it went into the hands of a receiver. Mr. Patten was away on a vacation. When he came back he found the property, the real estate, had passed into the possession of a man who held a claim on it, his obligation not having been met.

John C. Sparks.—May I ask the same question I asked Mr. Pownall? Is that merchantable ice?

A. J. Stahl.—Yes, sir, the ice is dense, white. We saw it up and it is as cleavable as is other ice. We distribute it to patrons we now have in South Bend. This plant was practically bankrupt a year ago. They attempted to manufacture and sell at wholesale to other distributors in town, seven of them. One of them, I don't know but what there were two, contracted to distribute vacuum ice. The lake ice they bought cost them $1.50, and the vacuum ice cost them $2.00 a ton, so they shoved into the people's ice-boxes the lake ice and put the vacuum ice back in the storage room and you know the result. I know about it; I visited the plant with a friend to show it to him and was induced, by a very flattering offer, to take a half interest in it. I did so and then found I had gotten into something. It needed enlarging, it had an output of 20 tons a day. To do business you must have a larger capacity. It was a rented building and there was no use to put other machinery in it. We looked about and found a plot of ground of about an acre, erected buildings on it, put in two boilers, an engine and generator and we are just now installing the freezers, four of them, that will have a capacity of 150 tons of ice a day; that is, allowing 18 tons a day for shrinkage during the hours that the freezers do not operate. We expect to make a freeze in sixty minutes; we do it now in an hour and a half with one absorber. In the new plant there will be two absorbers of the same capacity for each freeze, so I can get rid of the vapor from the freezer and make the ice quicker.

Mr. Grubmeyer.—I might add that the plant near Baltimore is still in operation. I was out there several weeks ago watching the process. They turn out very good ice. At the present time the local power company, with which I am associated, is figuring

upon changing it over to the electric proposition, but the ice in this case is used in dairy work for icing up milk and icing up the cans to keep the milk cool on the way in town. The process seems to be very successful; they do not seem to have any trouble and the ice looks very good.

G. T. Voorhees.—As there has been quite some discussion here on bacteria, I want to relate a little incident Mr. Patten showed me, for what it may or may not be worth. After having spoken about the ice being salable in that tombstone condition, I said, "How about bacteria?" He says, "Come over, Mr. Voorhees, and I will show you something;" and he took me to the vacuum pump, put two or three roaches in a glass, inverted it against a gasket and turned the vacuum pump onto it. The roaches blew up and burst. He said, "That is what happens to all the bacteria in the water from which we make ice, they blow up and burst, and there are no more bacteria in the water."

A. J. Stahl.—If you will come to South Bend at any time and bring a piece of skipper-cheese that, under the magnifying glass, you can see moving, we will put it in the vacuum and pull only ten inches of vacuum and then put it under a microscope and you will see that every one of them resembles a child's toy balloon—exploded at the stern end. As to the possibility of the obliteration of the bacteria, Mr. Glaser, who made the test at Baltimore in 1900 and again in 1902, found but the one colony, said, "The bacteria was obliterated before the freezing took place." There are two reasons that appeal to me why that is so; one is that no life exists in an absolute or nearly absolute vacuum; the other is that no bacteria is absolutely devoid of moisture, and when the pressure is relieved they do as the skippers do, blow up and explode.

R. F. Massa.—I had occasion to visit the Baltimore plant several years ago, with some engineers who were looking into the thing pretty carefully, and then later called on Mr. Glaser. Mr. Glaser at that time was not connected with the company, so what I say should be taken with that fact in mind, but Mr. Glaser's statement to me was that the water used in the plant was boiled and the water which he had tested for bacteria had been boiled. He had not known that at the time he made the tests, but later found it to be the case, and he described the apparatus which I had before seen in the plant as being the boiling apparatus.

John C. Sparks.—I would like to ask, if I should accept the invitation kindly extended to come to South Bend, Ind., might I bring cultures of bacteria to put in your ice?

A. J. Stahl.—Yes, sir, I shall be more careful about making statements in the future. I quoted from Mr. Glaser's written report. I did not know, nor did I ever hear Mr. Patten says that any water was boiled. His claim always has been that they used the raw water in making the ice. If the gentlemen saw the boiling apparatus and knows that, I will investigate thoroughly.

W. E. Parsons.—Perhaps it may not be known generally that Mr. Patten's first attempt in Baltimore was with a plant where he attempted to use an exhaust pump, or vacuum pump, of sufficient size to carry off all of the water vapor, so as to obviate the use of sulphuric acid. I have also heard that this plant cost about $350,000. It was built for a hundred-ton plant and I have understood that they did take out at one time as high as four blocks of ice in a day and that is the most they ever got out of it. One reason for this was, they tried to operate this plant on a different principle from that described by Mr. Stahl. A long, air-tight cylinder was located in a building about 34 feet from the ground floor, and in this cylinder was a movable belt, and a vacuum was supposed to be maintained in the cylinder by means of the vacuum pump, and water was sprayed on the belt. The partial evaporation of the sprayed water caused ice to freeze on the belt. Under one end of the belt there was a tank of water, and there was a conveyor to carry the ice down. When the ice came over this water it was supposed to be frozen thick enough and they chopped off a piece in the vacuum and it dropped in the water, and then part of the agitated tank water went into vapor and the pump had more than it could do and the vacuum was spoiled and it took them three to four hours before they got a vacuum again.

A. J. Stahl.—Permit me to suggest that during Mr. Patten's sixteen years of experimenting he went through different propositions that became obsolete. The present plant is different from the one used in Baltimore, where the top was taken off. At the present time, in our plant, the bottom is removable. There is a hydraulic elevator with a ring or gasket that makes an air-tight joint when pushed against the stationary shell, and when the freeze is done and the air let in, that bottom is let down with its load of ice. Very great improvements have been made. Mr. Patten told

me in conversation last fall that he had spent over $35,000 of his own money in experimenting. I never heard of so large an expenditure as the gentleman mentions. I heard of that immense pump that was 19 feet in diameter and 35 feet long; the cylinder took a five-story building to attempt to operate it. You might know that would be abandoned immediately; we need not give any further consideration to that process.

Thomas Shipley.—This gentleman says that Mr. Patten has been working on the vacuum system for sixteen years; I think it's a hundred and sixteen. I know that Mr. Patten has been working on this type of plant ever since I wore short breeches, at least ever since I have been connected with ice machinery. Some years ago I had occasion to send a testing crew to Baltimore to make a test run on Patten's vacuum plant. Some of the men who were on that crew are here with us to-day. The test was made to decide the amount of ice the plant could make per ton of coal. It made 111.65 tons of ice with 7 tons of coal, after which the plant required repairing, for it seemed to have a habit of going out of service for a while after each run. I know that Mr. Patten worked on this system for many years, gathering money for his experiments from one source and another, as his failures required it. Mr. Patten seems to be the only man who can run a vacuum system for even a limited time. He appears to be able to survive the fumes which come from that kind of a machine when it breaks loose, which it does very often, better that any other man I ever heard of. I guess those whom he leaves in charge are not as case hardened as he seems to be.

Some of you may have seen Mr. Patten step up to the faucet, which is connected with the vacuum chamber, place a glass full of water against the disk under the faucet, and when he opens the faucet, "zip," the glass contains nothing but ice. It is a very fetching little act, and to the man who does not know the secret, Mr. Patten stands in the light of a magician. In this way he has been able to interest man after man, who have put their money into the enterprise only to lose it in the end. This fact was brought home to me rather sharply only a short time ago when I found that a York man, who was a friend of mine, had committed suicide because he had not not only impoverished himself in backing Patten's vacuum system, but had also lost all the money his whole family possessed. Hence, it is hardly to be wondered at

that the vacuum system is a bad thing to do anything with but burn up money.

A. J. Stahl.—The gentlemen have spent their money and I am spending mine, for I am furnishing the money to build this new plant—$100,000.00—I have confidence in it. The gentleman has not seen the operation of this plant with its six freezers, and the ice coming down every day and being distributed to customers in South Bend, as is being done right along. He has not seen this; I do see it. He says it cannot be done and, if any of you do not believe that 29½ inches of vacuum can be pulled, come to South Bend and I will show it to you repeatedly. He says we cannot do it; I say to you we have done it and are doing it, and are going to continue to do it.

Louis Block.—I investigated the Baltimore plant in 1905; it was then a finished plant, had been experimented with three or four years before that. It made ice just as Mr. Stahl described, like a baked apple, and exactly the process he describes to-day was used at that time, except that instead of an elevator, the top was taken off and the ice was hoisted, which is a very small detail and does not change the condition of the plant. The ice looked, as he says, exactly like a block of marble. I asked Mr. Patten whether people wanted that ice. He said, "They are crazy for it, because they know this ice is pure; when they see ice which is as clear as glass, they know it is not pure." I was not there to argue with him; I wanted to see what he had. He assured me that Dr. Denton had made a calculation which figured out that nineteen tons of ice could be made per ton of coal. I asked him why he didn't put a boy at one door and weigh the coal which went in and a boy at the other door and weigh the ice which went out. He said, "It is not necessary, we are satisfied that that is what we can do." I asked him what he did with the trimmings, because he did not trim every block. He said he sold the ice to the fish men, and the reason there was a large quantity of that ice on hand at the time was because the fish trade was not very good just then. He said the plant could make a hundred tons, but was only making fifty at that time. Anyone who has any understanding of the ice business, and could see that plant, would never touch it with a ten-foot pole, because of the complexity of its machinery and its product. I have said to Mr. Patten, at a meeting in Philadelphia, that I regretted that he did not use his ingenuity in another direc-

tion, so as to benefit the world, because he is certainly an ingenious man and has perfected that system as much as it ever can be perfected. He has done a gigantic work, but it isn't worth anything.

D. S. Jacobus.—At the time Dr. Denton made the test, I compared the latent heat of the white ice which was produced with that of clear, distilled water ice. If the sample of ice was taken from a hard part of the cake and tested against the distilled water ice the latent heat values were identical. There was a contention made at the time that the ice was something like a moist snowball and carried a lot of water, but the tests indicated that the ice gave the same freezing effect as ordinary ice.

No. 115

Discussion of the topic—RECENT TYPES OF AMMONIA CONDENSERS AND THEIR EFFICIENCIES.

Louis Block.—My condenser is a matter of record, as it is patented and, consequently, everybody can get a full description of it. It has been described and illustrated in the trade journals. A very large number of them have been built and their efficiency has been proved to be approximately three to one, sometimes as much as four to one, as compared with the old style condenser. I received yesterday a paper from L. Stern & Company, of England, who made a test at the end of July, when I was present in Glasgow. It reads like this:

> "The following is a test we made of a set of Block condensers, which we built for a plant in Glasgow, consisting of two 100-ton De La Vergne machines, which have been operating for a number of years past on two sets of ordinary atmospheric condensers, each consisting of 7 stacks of condensers, 24 pipes high and 20 feet long = 3,360 lineal feet.
>
> "One of the compressors, working on one of the above sets of condensers, has been regularly making 50 tons of ice per day, and at the time of the test the condensing pressure in its set of atmospheric condensers was 175 pounds, suction pressure, 18 pounds, condensing water, initial temperature, 66.5 degrees F., the water being recooled in one of Heenan & Froude's patent coolers.
>
> "Recently a third compressor, exactly similar to the others, was installed, and this works with four Block flooded condensers, 16 pipes high and 20 feet long =1,280 lineal feet. The condensing pressure was only 170 pounds, suction pressure, 18 pounds, with condensing water of an initial temperature of 76 degrees F.
>
> "The condensing pressure was therefore 5 pounds less with Block flooded condensers of less than one-half the size, and when using condensing water 9.5 degrees F. higher temperature."

I want to say that, of those four condensers, three and a half were doing the work, as one-half of one condenser was cold. The York Manufacturing Company has built a lot of them and the Ruemmeli-Dawley Manufacturing Company have built a lot of them. They are in operation and some have been in operation for three or four years, so it is nothing new.

A. P. Criswell.—I can fully corroborate everything Mr. Block has said in regard to his condenser. I wish to state, however, that six months before Mr. Block made application for a patent on his condenser, I made application for identically the same thing. My application was turned down on account of one granted to T. L. Rankin. The patent was granted to Rankin 25 or 30 years ago, and has since expired. I don't know what Mr. Block put over on the board of examiners to get that patent, but he got it.

Louis Block.—You don't know when my application was made.

A. P. Criswell.—I read your patent. It shows for itself.

Louis Block.—But there was another application in two years before that.

A. P. Criswell.—I was not turned down on account of yours, but on account of Rankin's patent.

Louis Block.—Well, I am glad you confirm what the condenser will do.

A. P. Criswell.—I am glad to do that.

Thomas Shipley.—Supplementing what was said on the subject of flooded condensers at our last meeting, I will state that our company continued the investigations we were making at that time until quite late last Spring. In all we made over 350 runs of six hours each, working three test crews eight hours each per day, requiring nearly six months. This work consisted of, first, the best design of atmospheric condenser and, second, the capacity of such condensers under different head pressures, different temperatures of water and different quantities of water. Then we worked on the double pipe type of condensers through similar ranges, and we also worked on different combinations of condensers, such as batteries having one injector nozzle, etc. You will understand what a job this is when I call your attention to the fact that we worked out sufficient data to compile tables covering capacities of a section of condenser for each five degrees temperature of water from 55 degrees to 95 degrees, and for every ten pounds condensing pressure with each temperature of water, and also with 60, 45 and 30 gallons of water for each of these conditions. For instance, take 70 degrees condensing water, we have established the capacities of a section of two-inch pipe 20 feet long and twelve pipes high for 145, 155, 165, 175, 185, 195, 205, 215 pounds condensing pressures, taking the practical range of these pressures for each temperature of water, using at each pressure 60, 45 and 30

gallons of water per minute. This is twenty-four determinations for 70 degrees water. The average determinations made for each temperature of water was twenty and, as there were nine different temperatures used, the lowest pressure used was 115 and the highest was 235, in all one hundred and eighty determinations were required for the atmospheric type alone. From this you will get an idea of the amount of work required in these investigations. I am not in a position to give you this data at this time, but I will state that we obtained a transfer of 228 to 245 B. t. u. per square foot of surface per degree of mean difference. This will give you a line on the efficiency of this type of condenser.

As to a practical illustration of their efficiency, I will give you some facts that I gathered from one plant which I kept track of myself. This plant is a plate ice plant in Philadelphia, using cooling tower water. Last year it operated with thirteen coils of two-inch pipe, 20 feet long and twenty-four pipes high, or 6,240 feet of two-inch pipe; the condensing pressure averaged 200 pounds; the plant produced forty-six tons of ice per twenty-four hours during this period. This year, during the same period, the plant did 25 per cent. more work with a flooded condenser, consisting of eight coils of two-inch pipe, 20 feet long and twelve pipes high to a coil, or a total of 1,920 feet of two-inch pipe, made up of the identical pipe contained in the former condenser. The condensing pressure averaged 175 pounds. Cooling tower water being used in both periods.

This record is not unusual where flooded condensers replace the old atmospheric type. Some reports have reached me where even greater saving has been made, but the one I refer to I followed up in person and know the figures to be correct.

As to the number of these condensers in use, our records show we sold and put in operation over 25,000 tons capacity of flooded condensers since January, 1913, and more are being shipped out every day.

L. C. Nordmeyer.—Do you get the heat transfer you speak of on the old condensers?

Thomas Shipley.—Oh, no, the new ones.

L. C. Nordmeyer.—What was it on the other?

Thomas Shipley.—You can just figure back on the surface; we used 6,240 feet of pipe for 46 tons of ice in the old condensers, as against 1,920 feet for 60 tons with the flooded condenser. This

would be over 135 feet per ton in one case and 32 feet per ton in the other.

A. P. Criswell.—What size of your standard condenser, 12 pipes high, would you figure for 10 tons of ice?

Thomas Shipley.—Our tests showed that with 30 gallons of 70 degrees water, such a coil should give 10 tons ice making capacity and the condensing pressure should be between 165 and 170 pounds, with the pipes clean and the water properly distributed.

G. T. Voorhees.—I want to ask Mr. Block, or Mr. Shipley, perhaps, would answer it just the same, what the real object was in having the trap return bends on those coils, what difference it would make if the return bends were not traps?

Louis Block.—It doesn't make such a great difference, but it is better to have it so, because you are then sure your pipes are always filled one-third full of liquid; when you stop operation, the pipes remain one-third filled. If you start with a dry condenser, your pressure first goes up and as soon as liquid is produced it goes down, because the heat transference from the mixture of liquid and gas to water outside is so much more rapid than with dry gas to water outside.

Van R. H. Greene.—My interest in the question of the new condenser is not wholly a commercial one; it is more an engineering proposition, and it seems to me that is about the only question in connection with this condensers that has not been touched upon. We have been told that they were very much better than the old-style condensers, and, if so, there must be a fundamental principle behind it to do such work. There is no doubt but what they are doing a greater amount of work than were the old-style condensers, but the reason for it is quite clear. To Mr. Block belong the credit of devising a means whereby very much more water can be put over the condenser and kept in intimate contact with the condensing surface. Then, too, Mr. Block has found out by experience that the higher the gas velocity in the ammonia condensers, the higher will be the rate of heat transference. That is true in all standard engineering practice; it is true in the surface condensers; high vacuum condensers used on the torpedo boats where the water passes in at a high velocity, and the economy is due to that high velocity. The same is true of boiler practice. Mr. Ray of the United States fuel testing laboratory makes the bold statement that boilers are more efficient when

the baffle plates are arranged horizontally, than when they are arranged vertically. The same condition exists exactly in the present condensers. The name, flooded condenser, in my opinion, is an absolute misnomer. I do not think flooded has anything to do with the capacity; to get a heat of 223 B. t. u. you have got to have a gas velocity of something like 9,000 feet a minute. When you drop to a low velocity, such as you would normally find in a plant where the load was 15 tons of refrigeration, you will find the rate of heat transference so low that it will compare unfavorably with the old-style condensers.

D. S. Jacobus.—The Babcock & Wilcox Company has made a number of experiments to determine the law of heat transfer in a boiler. Our work in this line now enables us to install waste heat boilers under conditions where the expense of the installation would not have been warranted in our older practice. We are now experimenting with an apparatus to determine the exact law that connects the increase in the rate of heat transfer with the increase in the velocity of the gases. We have shown conclusively that the horizontal passage of the gases over the tubes will not give as good results as a cross passage, and have demonstrated beyond a doubt that the general statement which Mr. Greene has credited to Mr. Ray, that boilers are more efficient when the baffle plates are arranged horizontally than when they are arranged vertically, is incorrect.

Thomas Shipley.—I am very much surprised to hear that Mr. Greene has not struck nearer the true principle involved in the condenser he seems to think we have misnamed. I assure Mr. Greene that he is away off the track in his conclusions concerning the condenser we are discussing. He must have been asleep at our last meeting or he would have seen, from the sketches I made on the black-board, a reproduction of which is contained in Volume VIII of our Transactions, that the question of high velocity could not be a material element in the efficiency shown by the new type of condenser. To assume that velocity is the secret of the flooded condenser is the misnomer. However, I must take issue with Mr. Greene and his authorities, for the new condenser is not named wrong. It is actually a flooded condenser and there is no misnomer in its name.

If you will recall the explanation I gave you as to how I began to experiment on this apparatus and how I developed the con-

denser which bears my name, the "Shipley Flooded Condenser," you will see that the principle involved is simply "The condensation of a gas by bringing it in contact with its own liquid," and then keeping the temperature if the liquid low enough to continue the condensing operation by circulating the liquid through another part of the apparatus, where it is cooled and part of it returned to the condensing chamber. The increased transfer of heat to the cooling water in this type of condenser is because there is liquid on both sides of the surface through which the heat passes. It is liquid to liquid instead of gas to liquid, as in the old type. As a matter of fact, the velocity with which these liquids flow past the suface through which the heat transfer takes place is exceedingly slow. Mr. Greene should get over this misnomer idea of his, as he is certainly wrong in his assumption.

Van R. H. Greene.—Let me ask the gentleman just one question; why is it that on these same high-efficiency steam condensers particular pains are taken to insert baffle plates so as to remove the water as fast as it is condensed? If what Mr. Shipley said were true, if there were liquid lying in the condenser the way he claims there is, then the movement of that liquid would be so infinitesimally slow there would be no rate of heat transfer anything like what is obtained in actual practice.

G. T. Voorhees.—I believe that I am in between Mr. Greene and Mr. Shipley. It seems to me that the reason this flooded condenser is so efficient is that for a given difference in temperature the transfer of heat from a liquid to a liquid through metal is very much more intense than the heat transferred from a liquid to a gas through metal. The bubbles of gas in the liquid present much more surface to the liquid to cool and condense them than they could present to the surface of the tube, and you get the cooling of the liquid inside by the water outside.

Thomas Shipley.—As I explained to you last year, the thought which led me to experiment with the condenser we are discussing was that ammonia gas could be readily condensed by bringing it into contact with its liquid in the same manner that steam is condensed when it is brought into contact with water. I realized that if this could be done, it would be necessary to cool the liquid which did the condensing or it would soon become so hot that it would cease to act as a condensing medium.

By referring to the discussion I made on this type of condenser at our meeting last December, which is given in the 1912 Transactions, just published, you will find a sketch I made called Fig. 1. This sketch shows an apparatus I had constructed after experimenting with many others, and it serves to illustrate the point I want to make very clearly. You will note that the body of the apparatus is a shell or drum with heads at each end, which heads are connected with tubes, similar to boiler practice. The shell is filled with liquid ammonia to a point near the top. The condensing water passes through the tubes from the bottom to the top. The ammonia gas is condensed in the tee shaped condensing chamber, which is outside of the shell. The gas enters the bottom of this chamber, where it is condensed by coming in contact with the liquid entering this condensing chamber, through the side pipe connecting it with the bottom of the liquid section of the shell. The resultant being driven upward through the pipe which connects the condensing chamber with the top of the ammonia section of the shell. This resultant enters the ammonia space at or above the liquid level, and the cooling is effected when the liquid is going down, at a very slow velocity, through the shell, which was about 20 inches in diameter and about five feet long. The capacity obtained by this apparatus was about 30 tons refrigeration. I do not remember the temperature and quantity of water. There is no question about the height of the liquid, for we had glass gauges arranged to show the liquid from top to bottom, and we also strapped a thermometer on the body of the shell every foot, from top to bottom, to keep track of the temperatures at these points and also to determine the effect of raising and lowering the liquid level. As I explained to you before, we obtained a greater capacity as we raised the liquid level, thus bringing more liquid surface into contact with the water surface. Velocity had nothing to do with the transfer of heat; absolutely nothing. The ammonia gas was condensed by bringing it in actual contact with the liquid and the resultant was circulated back through another part of the apparatus, where it was cooled and part of it used over again (a portion of the liquid being drawn off into the general system). The same principle is carried out in all other designs of this apparatus, as will be seen by analyzing them.

The heat produced by the condensation of the gas is taken up by the resultant liquid which is cooled in the cooling chamber.

and part of the cooled liquid returned to the condensing chamber to continue the cycle.

The amount of work the condensing apparatus can do depends upon the temperature and quantity of the liquid entering the condensing chamber, hence the capacity or efficiency of the apparatus is governed by the transmission of heat to the cooling water. The surface of this part of the apparatus is made very effective because there is liquid on both sides of this surface. The whole question of efficiency resolves itself to a transfer of heat from a liquid to a liquid, but not to velocity.

H. D. Pownall.—I think that Mr. Shipley made the proposition very plain in the last three words he said in his first talk, and that is, it is simply a matter of transfer of heat from a liquid to a liquid. That has been demonstrated by Prof. Denton at least fifteen years ago, and I remember one passage in one of Kent's handbooks where he made the statement that the transmission under certain conditions was about eleven times as great from liquid to liquid as it was from liquid to gas, and it is simply a case of condensing the gas by the liquid and then transferring the heat from the liquid to the water on the outside of the pipe. I am like Mr. Shipley, I don't think the velocity has anything to do with it whatever.

Van R. H. Greene.—Those figures are based again on velocity. Nobody denies that liquid to liquid heat transference with the same velocity is more efficient than gas to gas. Those figures are based on similar conditions of velocity. If there is no velocity there is no rate of heat transference.

J. J. Wuertenbaccher.—Referring to our experience in connection with the so-called Block patented flooded ammonia condenser, I must say that in each and every case the result has been an improvement over and above the old ammonia condensers.

The object of the invention was to enable ice and refrigerating machines to be operated a great deal more economically than has heretofore been possible with the ordinary atmospheric condenser in use. The increased economy is gained in several ways, first, by reduced first cost of condenser and, secondly, with the Block flooded condenser a much lower condensing pressure is obtained with a given temperature of condensing water. The liquid leaves the condenser at the initial temperature of water supply when the condenser is of proper height.

The first cost is less, because owing to the principle involved a more rapid heat interchange is brought about and hence the amount of condensing surface required is materially reduced. For water under 70 degrees we use 12½ lineal feet per ton and with water from 70 to 90 degrees we use 16 lineal feet of 2 in. pipe per ton.

A saving of 10 per cent. in power can be made with the use of the Block condensers.

The gas is entered at the bottom and the liquid leaves the top of the condenser through a trap, the condensing header always being elevated above the liquid header to prevent the possibility of liquid laying in the discharge pipe.

The Block condenser, as intended to be built by Mr. Block, has four or five times greater efficiency per lineal foot of condensing surface than the different types of condensers. The new method employed by Mr. Block has entirely divorced the old principle of draining off the liquid ammonia as soon as it is formed. Contrary to this, the ammonia, after it has been liquefied, is held in the condenser and made use of as a heat carrier or heat conveyor. The hot gas coming from the compressor is injected in the bottom pipe of the condenser and as the liquid is taken off at the top the condenser is operated "flooded." The ammonia liquid, into which the hot gas is sprayed, condenses the hot gas very readily, takes up the heat of compression and conveys it through the water cooled pipe surface into the cooling water on the outside. The condensers are provided with drip strips between the pipes to convey the water from the top pipe to the bottom pipe, preventing the water from spattering off.

The Block ammonia condenser reduces the condensing pressure, resulting in less strain on the working parts of the machine, as well as a saving in fuel. Less space is required, as one Block condenser does the work of about four stands of ordinary condensers; less weight has to be carried on the condenser floor, hence cheaper superstructure; condenser pan is much smaller and cheaper on account of less number of condensers; less chance for cleakage on account of less number of stands to be handled.

The liquid leaving the condenser at almost the initial temperature of the cooling water is one of the greatest advantages of this condenser.

The cost of the Block condenser per tonnage is a great deal cheaper than any other type and the cost of maintenance is reduced in proportion to the less number of stands.

At the big ice manufacturing plant of the Anheuser-Busch Brewing Association, in St. Louis, Mo., during the season of 1912, ten stands of Block condensers, 20 pipes high and 20 feet long, have averaged 230 tons of ice, while at times 250 tons of ice have been made with them, or, in other words, 25 tons of ice with one stand. The condensing water used was cooled by a cooling tower.

In the Fall of 1912, at the plant of the Polar Wave Ice & Fuel Company, where the water to the condensers was supplied from three cooling towers, it happened that only one cooling tower could be operated on account of some necessary repairs to the generator engine. Through the temporary shortage in cooling tower capacity the water reached the Block condensers at 98 degrees. This excessive warm water would have made the shut-down of the plant imperative with any other condenser, while the condition did not seriously affect the plant at all with the Block condensers. Handicapped with this warm water for a couple of days, the plant produced with 20 stands of Block condensers its maximum capacity of 300 tons of ice and in addition to that refrigerated a very large ice storage. In spite of the warm condensing water, the highest pressure was only 210 pounds.

The following data were taken at the Anheuser-Busch Bronx Agency plant, New York, N. Y., in July 1911; condensers being 18 pipes high and 20 feet long and operating on two 17¼ in. x 34 in. Vilter compressors, speed 58 revolutions per minute; suction pressure 20 pounds:

7 condensers in service—		
Initial temperature of water.....	56	deg. F.,
Final temperature of water.....	80	"
Condenser pressure	151	lbs.
6 condensers in service—		
Initial temperature of water.....	56	deg.
Final temperature of water.....	79	"
Condenser pressure	157	lbs.
5 condensers in service—		
Initial temperature of water.....	56	deg.
Final temperature of water.....	83	"
Condenser pressure	153	lbs.

4 condensers in service—

Initial temperature of water	56	deg.
Final temperature of water	80	"
Condenser pressure	151	lbs.

Why there was less work performed when six condensers were in service than when five condensers were in service, can only be explained by stating that the ice making system in connection with which the compressors are operating is a flooded system, in which the suction pressure often varies and cannot be accurately controlled. We presume during the test showing less work the suction pressure was slightly lower and in the other instances it was slightly higher than during the first and last readings.

On November 4, 1911 another test with three condensers was made, the water being heated to a temperature equal to that of bathing water temperature in Texas, and operating one 17¼ in. x 34 in. Vilter compressor at 57 revolutions, with a suction pressure of 22 pounds.

Initial temperature of water	84	deg., F.
Final temperature of water	95	"
Condenser pressure	200	lbs.
Initial temperature of water	84	deg.
Final temperature of water	96½	"
Condenser pressure	205	lbs.

2 condensers in service—

Initial temperature of water	84½	deg.
Final temperature of water	96	"
Condenser pressure	212	lbs.

Some data taken at various plants using Block condensers follow:

Anheuser-Busch Brewing Association, St. Louis, June 9, 1913 —one 18 in. x 36 in. (two compressors), double acting D.L.V. vertical refrigerating machine, making 120 tons of ice.

Initial temperature of water	70	deg., F.
Final temperature of water	84	"
High pressure	165	lbs.
Back pressure	25	"

Operated on 7 Block condensers 20 pipes high, 20 feet long, or a total of 2,800 lineal feet of 2 inch pipe.

At the same time another 18 in. x 36 in. D.L.V. machine was making 115 tons of ice, operated on 14 D.L.V. condensers, 24

pipes high, 20 feet long, or a total of 6,720 lineal feet of 2 inch pipe.

Initial temperature of water	70	deg., F.
Final not taken		
High pressure	180	lbs.
Back pressure	16	"

June 10, 1912, one 18 in. x 36 in. (two compressors),double acting D.L.V. vertical machine was making 120 tons of ice, operated on 7 Block condensers, 20 pipe high, 20 feet long.

Initial temperature of water	70	deg., F.
Final temperature of water	82	"
High pressure	160	lbs.
Back pressure	25	"

At the same time another 18 in. x 36 in. D.L.V. machine was making 115 tons of ice, operated on 14 D.L.V. condensers, 24 pipes high, 20 feet long.

Initial temperature of water	70	deg., F.
High pressure	180	lbs.
Back pressure	15	"

June 21, 1912, one 18 in. x 36 in. D.L.V. vertical (two compressors), double acting machine, operating at 44 revolutions, making 120 tons of ice; operated on 7 stands of Block condensers, 20 pipes high, 20 feet long.

Initial temperature of water	70	deg., F.
Final temperature of water	84	"
High pressure	165	lbs.
Back pressure	22	lbs.

At the same time one D.L.V. machine, 18 in. x 36 in., vertical, double acting, was operated at 35 revolutions, using 14 D.L.V. condensers, 24 pipes high, 20 feet long.

High pressure	175	lbs.
Back pressure	14	"

July 25, 1912, two D.L.V. compressors (2 cyl. each), vertical, double acting machines, 18 in. x 36 in., making 235 tons of ice, operated on 10 stands Block condensers, 20 pipes high, 20 feet long.

Initial temperature of water	84	deg., F.
Final temperature of water	97	"
High pressure	215 to 220	lbs.
Back pressure	22	lbs.

Kansas Ice & Storage Co., Salina, Kansas, June 26, 1912, one horizontal, double acting, 15 in. x 30 in. compressor, 60 revolutions per minute, doing about 90 tons of work, operating on two Block condensers, 22 pipes high, 20 feet long.

Initial temperature of water	60	deg., F.
Final temperature of water	82	"
High pressure	160	lbs.
Back pressure	20	"

Belz Provision Co., St. Louis, July 25, 1912, one 11 in. x 17 in., horizontal, double acting single compressor runnning at 80 revolutions per minute, doing about 36 tons of work, operated on two Block condensers.

Initial temperature of water	80	deg., F.
Final temperature of water	94	"
High pressure	200	lbs.
Back pressure	18	"

There was a lot of air in the system at the time this data was taken.

Another test, August 5, 1912, one 11 in. x 17 in., double acting single compressor (the same machine as mentioned in preceeding paragraph), running at 78 revolutions per minute, doing 35 tons of work operated on one Block condenser, 22 pipes high, 20 feet long.

Initial temperature of water	74	deg., F.
Final temperature of water	88	"
High pressure	180	lbs.
Back pressure	14	"

Carondelet Packing Co., St. Louis, Aug. 5, 1912, one 8¼ in. x 16 in. double acting single compressor, running about 92 revolutions per minute, doing 20 to 25 tons of work, operated on one Block condenser, 22 pipes high, 20 feet long.

Initial temperature of water	57	deg., F.
Final temperature of water	74	"
High pressure	136	lbs.
Back pressure	16	"

Polar Wave Ice & Fuel Co., St. Louis, Aug. 7, 1912, two vertical machines, single acting, with four 22½ in. x 36 in. single acting compressors, running 66 revolutions per minute, making 275 tons of ice, and taking care of an ice storage of about 800,000 cubic feet, total amount of work being 550 tons refrigerating ca-

pacity, operated on 18 stands Block condensers, 20 pipes high, 20 feet long.

This Polar Wave plant used to be operated on 36 double pipe ammonia condensers made of 3 inch and 2 inch pipe, 12 pipes high, 20 feet long. Outside of these condensers it had two ammonia double pipe liquid coolers, made of 3 inch and 2 inch pipe, each 4 pipes high, 20 feet long. The double pipe condensers were also flooded with water on the outside, and the average high pressure was 240 pounds in summer.

The operating engineer informs us that he is pumping about half the amount of water on Block condensers from what was used and that he notices a considerable saving in steam and coal. The double pipe condensers caused a high head pressure on account of excessive friction in the water flow.

Initial temperature of water..... 87 deg., F.
Final temperature of water..... 100 "
High pressure ..... 208 to 210 lbs.
Back pressure ..... 17 lbs.
August 8, 1912—
Initial temperature of water..... 84 deg., F.
Final temperature of water..... 97 "
High pressure ..... 200 lbs.
Back pressure ..... 17 "
Making 278 tons of ice and taking care of the ice storage.
August 9, 1912—
Initial temperature of water..... 80 deg., F.
Final temperature of water..... 94 "
High pressure ..... 190 lbs.
Back pressure ..... 20 "
Making 278 tons of ice and taking care of the ice storage.
August 16, 1912 (twenty stands in service)—
Initial temperature of water..... 88 deg., F.
Final temperature of water..... 100 "
High pressure ..... 210 lbs.
Back pressure ..... 17 "
Making 277 tons of ice and taking care of ice storage.

The construction of the Block condenser is similar to the atmospheric condenser, made of 2 inch pipe, screwed into return bends. The hot gas being admitted to the bottom pipe and the liquid drained from the top pipe. A somewhat larger slotted water

pipe is supplied with this condenser and the slots are also somewhat larger, in order to permit the condenser being flooded with water on the outside.

A battery of these condensers is usually furnished with the usual hot gas header, liquid header, liquid drain header and pump-out and equalizing header, which connects to a blow-off tank where all of the air accumulates and from which it may be blown off. Each section is supplied with the usual valves for shutting off the gas and liquid should it be necessary. It has been found that these condensers require regulation at the gas inlet valve in order that the gas be equally distributed to all of the working sections. If the condensers are provided with an injector nozzle at the gas inlet point the valve need not be so accurately regulated.

Before starting up this condenser the valves must necessarily be opened and pipes flooded with water. Start the machine slowly, until condensers are filled with ammonia. Each section of Block condenser, 22 pipes high, 20 feet long, requires a charge of ammonia of about 300 pounds in order to make it work flooded. Care must be taken that not too much ammonia is in the system. In case of overcharge of ammonia, you will find that the machine will be discharging against a liquid head which would materially raise the high pressure, and to avoid this we recommend the installation of large liquid storage tank or an additional section of condenser for storing the ammonia. Should any section require pumping out on account of leakage, the drain header will permit the draining of the liquid from the condenser.

I estimate that about 5 cubic feet of liquid storage capacity should be provided for each stand of condenser, 22 pipes high, 20 feet long.

To insure a steady flow of liquid it is necessary to equalize your liquid storage tank or receiver with the condensers and purge the air from the system through the air accummulator provided. It should be borne in mind that the water passing over the ammonia condensers does the work of cooling the water used for ice-making purposes, the condenser being only a medium of transmitting the heat absorbed by the ammonia.

I herewith give the condenser pressures as they should check up with the final temperature of water in the condenser pan. If the gauge pressure should be higher it is caused principally by air or noncondensible gases in the system, or else it may be due to

an insufficient amount of ammonia in the system or the gauge being incorrect.

Water Temp.F.	Gauge Press. lbs.	Water Temp. F.	Gauge Press. lbs.	Water Temp. F.	Gauge Press. lbs.	Water Temp, F.	Gauge Press. lbs.
70	126	80	152	90	182	100	215
71	129	81	155	91	185	101	218
72	131	82	158	92	188	102	221
73	134	83	161	93	192	103	225
74	136	84	164	94	195	104	228
75	139	85	167	95	198	105	232
76	142	86	170	96	202	106	235
77	144	87	173	97	205	107	239
78	147	88	176	98	209	108	242
79	150	89	179	99	212	109	246

PROCEEDINGS

OF THE

NINTH ANNUAL MEETING

NEW YORK, N. Y., December 1 and 2, 1913.

The American Society of Refrigerating Engineers held its ninth annual meeting in the Engineering Societies' Building, 29 West Thirty-ninth street, New York, N. Y., on Monday and Tuesday, December 1 and 2, 1913. Four sessions were held, Monday morning, afternoon and evening and Tuesday morning, all being called to order and presided over by President Peter Neff, Canton, Ohio.

First Session, Monday Morning, December 1

The first session of the meeting was called to order at about 10 o'clock A. M., and, as more than a quorum for the transaction of business was present, President Neff announced that the calling of the roll of membership would be dispensed with.

The minutes of the Eighth Annual Meeting, as well as the Third Western Meeting, was read and approved.

The next order of business was the report of the Tellers of Election of Members. It follows:

REPORT OF TELLERS OF ELECTION OF MEMBERS

NEW YORK, N. Y., November 26, 1913.

MR. PETER NEFF, President,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York, N. Y.

DEAR SIR:—Your Tellers of Election of Members beg to report that they met on the morning of November 26 and canvassed the ballots for new members closing on November 25.

They found 131 ballots cast, 3 of which were void for the lack of signature on the outer envelope.

They find that the following applicants have been elected to membership in the grades indicated:

MEMBER

Henry J. Engel...New York, N. Y.
Emil Joseph Etienne, San Francisco, Cal.
Frank L. Fairbanks...Boston, Mass.
William D. Monks, New York, N. Y.
George W. Schoephoester, St. Louis, Mo.
Thomas Vaughan.....Chicago, Ill.
Emil Vilter.....Milwaukee, Wis.
George E. Wallis, New York, N. Y.

ASSOCIATE MEMBER

Alfred B. Jenks, Moorestown, N. J.
Emil Peter.....Louisville, Ky.
Harry A. Poth....Philadelphia, Pa.
F. E. Robertson,
Wichita Falls, Texas
William D. Sweet,
Siloam Springs, Ark.
Harold B. Wood.....Hudson, N. Y.

JUNIOR MEMBER

Francis L. Bein...Kansas City, Mo.
Ralph N. Cole.....Canton, Ohio
Samuel R. Phelps, Philadelphia, Pa.

FOR CHANGE OF GRADE OF MEMBERSHIP FROM JUNIOR MEMBER TO MEMBER

Richard Broas, New York, N. Y.

Respectfully submitted,

(Signed) GEORGE H. LANE, *Chairman,*
ROBERT N. BAVIER,
} *Tellers of Election of Members.*

The president then declared the successful applicants for membership duly elected to their respective grades and entitled to the rights and privileges of membership, provided they had complied with the provisions of the Constitution and By-Laws relating to new members.

The report of the Council was next in order. It follows:

REPORT OF THE COUNCIL OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS FOR THE FISCAL YEAR ENDING NOVEMBER 29, 1913.

The Finance Committee report contains all the receipts and disbursements of the Society during the year. It is as follows:

REPORT OF FINANCE COMMITTEE

NEW YORK, N. Y., November 29, 1913.

MR. PETER NEFF, President,
The American Society of Refrigerating Engineers,
154 Nassau street, New York, N. Y.

DEAR SIR:—Your Finance Committee begs to report the following receipts and disbursements for the fiscal year ending November 29, 1913:

Balance on hand November 30, 1912		$400.98
RECEIPTS		
Dues	$1,722.16	
Initiation fees	160.00	
Emblems	90.97	
Transactions, etc.	326.79	
Furniture	9.00	
Dinner tickets	385.00	
Deficit fund contributions	1,526.50	
Refrigeration Congress fund contributions	205.25	
Total		4,425.67
Grand total		$4,826.65
DISBURSEMENTS		
Stenographic transcripts Eighth Annual Meeting and Third Western Meeting	$155.95	
Caterers	636.81	
Printing	1,314.29	
Emblems	83.25	
Engrossing membership certificates	9.50	
Rents	381.35	
Furniture	113.00	
Salaries	1,250.00	
Petty cash	319.53	
Booth International Refrigeration Exposition	149.50	
Advertising transactions	119.50	
Badges, Third Western Meeting	43.75	
Miscellaneous	50.00	
Total		4,626.43
Balance on hand		$200.22

Respectfully submitted,

(Signed) THOMAS SHIPLEY, *Chairman.*

The Council held three executive sessions during the year as follows:

January 21, 1913, at New York, N. Y., with President Neff presiding.

September 23, 1913, at Chicago, Ill., with President Neff presiding.

October 22, 1913, at New York, N. Y., with Vice-President Kolischer presiding.

The Council respectfully presents herewith a report of the business transacted at these meetings, along with other matters that should be of interest to the membership.

At the first meeting of the Council, W. H. Ross was reappointed Secretary of the Society and $1,500 was appropriated to cover his salary and the salary of an office stenographer, as well as to cover any special editorial services.

The resignations of three members were accepted during the year and four members have been dropped from the membership roll on account of non-payment of dues.

The Membership Committee presented the following approved applications for membership on the dates given and they have received the favorable action of the Council in the grades indicated:

January 21, 1913—

MEMBERS

Herbert E. Smith, Boston, Mass.
Norman M. Small, Waynesboro, Pa.
J. I. Lyle, New York, N. Y.
S. B. Carpender, New Brunswick, N. J.

ASSOCIATE MEMBERS

F. S. Russell, Chicago, Ill.
W. H. Dohrmann, Brooklyn, N. Y.
Arthur Gifford, Hudson, N. Y.
Charles J. Hackett, Brooklyn, N. Y.
W. L. Glatfelter, York, Pa.

JUNIOR MEMBERS

L. A. Ramsey, New York, N. Y.
Frederick J. Byrne, New York, N. Y.
Guy W. Jacobs, York, Pa.
Gilbert H. Crawford, Jr., Washington, D. C.
Clarence W. Vogt, Louisville, Ky.
E. Montague Frid, Philadelphia, Pa.

September 23, 1913—

MEMBERS

Frank L. Fairbanks, Boston, Mass.
Thomas Vaughan, Chicago, Ill.

ASSOCIATE MEMBERS

Alfred B. Jenks, Moorestown, N. J.
Emil Peter, Louisville, Ky.
Harry A. Poth, Philadelphia, Pa.
F. E. Robertson, Wichita Falls, Texas.
Will D. Sweet, Siloam Springs, Ark.
Harold B. Wood, Hudson, N. Y.

JUNIOR MEMBERS

Samuel R. Phelps, East Orange, N. J.

October 22, 1913—

MEMBERS

Henry J. Engel, New York, N. Y.
Emil J. Etienne, San Francisco, Cal.
William D. Monks, New York, N. Y.
George W. Schoephoester, St. Louis, Mo.
Emil Vilter, Milwaukee, Wis.
George E. Wallis, New York, N. Y.

JUNIOR MEMBERS

Francis L. Bein, Kansas City, Mo.
Ralph N. Cole, Canton, O.

Those approved on January 21, 1913, were formally accepted into membership at the Chicago meeting on September 18, while the others have been formally installed at this meeting.

Richard S. Broas, New York, N. Y., has been advanced in membership from Junior Member to Member.

At the meeting of the Council on January 21, President Neff announced the following committee appointments:

MEMBERSHIP COMMITTEE

Henry Torrance, Jr., Chairman, New York, N. Y.
Louis Doelling, New York, N. Y.
Carl Behn, New York, N. Y.

FINANCE COMMITTEE

Thomas Shipley, Chairman, York, Pa.
Ezra Frick, Waynesboro, Pa.
Louis Block, New York, N. Y.

PUBLICATION COMMITTEE

Edward N. Friedmann, Chairman, New York, N. Y.
L. C. Nordmeyer, St. Louis, Mo.
J. H. Stone, New York, N. Y.

PROGRAM COMMITTEE

Theodore Kolischer, Chairman, Philadelphia, Pa.
Henry Vogt, Louisville, Ky.
Theodore O. Vilter, Milwaukee, Wis.
John Levey, Chicago, Ill.
C. H. Young, New York, N. Y.

NOMINATING COMMITTEE

R. H. Tait, Chairman, St. Louis, Mo.
Edgar Penney, Newburgh, N. Y.
D. S. Jacobus, New York, N. Y.
W. E. Parsons, Newark, N. J.
John E. Starr, New York, N. Y.

TELLERS OF ELECTION OF MEMBERS

George H. Lane, Chairman, New York, N. Y.
John R. Livezey, Philadelphia, Pa.
Robert N. Bavier, New York, N. Y.

He also appointed the following special committees as per resolutions passed at the Eighth Annual Meeting:

TEMPORARY PHYSICAL CONSTANTS COMMITTEE

Charles E. Lucke, Chairman, New York, N. Y.
Thomas Shipley, York, Pa.
V. R. H. Greene, New York, N. Y.
F. L. Pryor, Hoboken, N. J.
Richard Broas, New York, N. Y.

STANDARDIZATION OF AMMONIA FITTINGS COMMITTEE

Thomas Shipley, Chairman, York, Pa.
Theodore O. Vilter, Milwaukee, Wis.
Henry Vogt, Louisville, Ky.
Louis Doelling, New York, N. Y.
Ezra Frick, Waynesboro, Pa.

COMMITTEE ON STANDARD BASIS FOR FINDING THE FUEL ECONOMY OF STEAM DRIVEN ICE MANUFACTURING PLANTS

N. H. Hiller, Chairman, Carbondale, Pa.
A. P. Criswell, Chicago, Ill.
H. D. Pownall, Canton, Ohio.
George E. Wells, St. Louis, Mo.
Edward W. Gallenkamp, Jr., St. Louis, Mo.

At the meeting on January 21 a motion prevailed authorizing the appointment of a Special Finance Committee to secure contributions to a fund to make up the Society's deficit. President Neff appointed the following members on this committee:

C. H. Young, Chairman, New York, N. Y.
Carl Behn, New York, N. Y.
Henry Torrance, Jr., New York, N. Y.

This committee secured contributions amounting to $1,526.50 to this fund, which, if the entire membership had paid up their dues, would have entirely liquidated the Society's obligations up to date. However, obligations of a total of about $1,000 remain unpaid, but this will be met from the dues for 1914, unless the Council makes other provisions to meet its obligations.

As a matter of interest to the membership, our Transactions are now complete to date, Volume VIII, for 1912, having been issued in September.

Heywood Cochran, Chicago, Ill., was appointed a Director to fill the unexpired term of Victor H. Becker, deceased, at the meeting on January 21, and at this same meeting the Secretary was instructed to secure additional office space in the Tribune Building, New York, N. Y., and $550 was appropriated to cover the office rent for 1913.

A motion prevailed at the meeting on January 21, authorizing the President to appoint a committee to promote discussion by the members of the Society on the papers presented at the Third International Congress of Refrigeration, particularly on those papers presented by foreigners. President Neff appointed the following members on this committee:

P. D. C. Ball, Chairman, St. Louis, Mo.
Heywood Cochran, Chicago, Ill.
J. C. Goosmann, Chicago, Ill.
John C. Atwood, St. Louis, Mo.
R. H. Tait, St. Louis, Mo.

At this same meeting the President was also instructed to appoint a committee to co-operate with the New York General Committee for Entertaining the Third International Congress of Refrigeration in receiving and entertaining foreign delegates arriving at the port of New York. He appointed on this committee:

F. L. Pryor, Chairman, Hoboken, N. J.
Gardner T. Voorhees, New York, N. Y.
Karl Vesterdahl, New York, N. Y.
John E. Starr, New York, N. Y.
Louis Block, New York, N. Y.

At the meeting on January 21 an appropriation was authorized not to exceed $150 to advertise for sale the volume of our Transactions. The printing of 500 copies of the 1912 Transactions as well as 500 copies of the 1913 Year Book was also authorized at this meeting.

Motions also prevailed at the meeting on January 21 authorizing the holding of a special meeting of the Society in Chicago, Ill., in September, at the time of the Third International Congress of Refrigeration, which was held in the Hotel La Salle on the afternoon of September 18, and the President appointed the following members as a Special Program Committee to co-operate with and work under the supervision of the Program Committee:

F. W. Pilsbry, Chairman, Chicago, Ill.
A. P. Criswell, Chicago, Ill.
E. F. McPike, Chicago, Ill.
John Levey, Chicago, Ill.
C. L. Whittemore, St. Louis, Mo.

The purchasing of additional office furniture not to exceed in cost $100 was authorized at the meeting on January 21.

The letter ballot of the Council relative to the reinstatement of Fred Nolde as a member, who resigned his membership in 1911, on the payment of back dues was affirmed at the meeting on September 23, as was also the letter ballot of the Council relative to the Society having a booth at the International Exposition of Refrigeration.

On the invitation of Charles Lathrop Pack, President of the Fifth National Conservation Congress, President Neff was authorized at the meeting on September 23 to appoint a committee of five to represent the Society at this Congress to be held in Washington, D. C., on November 18, 19 and 20. President Neff appointed the following members on this committee.

William M. Chatard, Chairman, Baltimore, Md.
George W. Wright, Baltimore, Md.
Irving Warner, Wilmington, Del.
A. B. Strickler, York, Pa.
R. J. Berryman, Annapolis, Md.

The resignation of Junius H. Stone as a Director of the Society, who is now residing in Palamos, Spain, was accepted with regret at the meeting on September 23.

The invitation of The American Society of Civil Engineers, The American Society of Mechaniccal Engineers, The American Institute of Electrical Engineers and The Society of Naval Architects and Marine Engineers, inviting the Society to participate in the International Engineering Congress to be held in San Francisco in 1915, at the time of the Panama-Pacific International Exposition, was considered at the meeting on September 23, and the Secretary was instructed to acknowledge receipt of the invitation, accompanied by a statement that while the Society would be pleased to co-operate with the International Engineering Congress, the extent of this co-operation will be determined at a later meeting of the Council of the Society. The Council therefore requests suggestions from this meeting as to holding our Fourth Western Meeting in San Francisco at that time. We have quite a number of members on the Pacific Coast who seldom find it convenient to attend our annual, as well as western meetings, and who would no doubt attend a meeting held in San Francisco, besides at the same time broadening the influence and usefulness of the Society.

At the meeting on September 23 the exchange of our Transactions for

the publications of the Western Society of Engineers, Chicago, Ill., was authorized, as was also an appropriation of $100 to purchase hand and text books on refrigeration and its applications for our library.

At this same meeting the Secretary was instructed to withhold the bills for dues for 1914 until after this meeting to await its action on the amendment introduced at the Eighth Annual Meeting proposing an increase in the dues for the various grades of membership.

Fausto Scerno, Genova, Italy, has presented the Society with handsomely bound volumes of the Italian periodical "L'Avvenire Economico e le Industrie del Freddo." A complete set of our Transactions have been sent him in appreciation of his generosity.

It is with sincere regret that we must announce the death of Ex-President Edgar Penney, who died of apoplexy in Auburn, N. Y., on November 14. He was buried at Newburgh, N. Y., on November 18. The Society was represented at the funeral by Ex-Presidents Block and Starr, Ex-Vice-President Roelker and Ex-Director Jenks. Floral offerings were sent to his family.

We also sincerely regret to announce the death of our fellow member, Albert J. Golden, Philadelphia, on September 24, 1913. We hope appropriate resolutions will be presented at this meeting on the life work of these beloved members.

At our Eighth Annual Meeting William Earl Mosher of the University of Illinois presented a very able paper on "The Properties of Saturated and Superheated Ammonia Vapor." At that time Mr. Mosher had not completed his investigations, and in January of this year the University of Illinois issued in pamphlet containing results of the complete work. A copy of this pamphlet was mailed to each member through the courtesy of the University of Illinois.

During the past year the Society has established an Employment Bureau for its members and others, through which members may secure employment and employers secure employes. The extent of the usefulness of this department depends entirely upon the use made of it by the membership and we ask your co-operation in making it a success.

Your President has appointed the following members as Tellers of Election of officers:

Henry Vogt, Chairman, Louisville, Ky.
A. W. Sterrett, Tacoma, Wash.
John N. Briggs, Coeymans, N. Y.

The importance of the work done and the prominent part taken in the Third International Congress of Refrigeration by members of this Society should be gratifying to us all, and your President feels that this Societv and its members are to be congratulated for a goodly share of the success of the Congress.

Our booth at the International Refrigeration Exposition was generously visited by our members, where they found a comfortable place to rest and conduct their correspondence.

The Society issued a pamphlet for distribution at both the Third International Congress of Refrigeration and the International Refrigeration Exposition. This pamphlet contained the list of past and present officers,

a reprint of your President's paper on "The American Society of Refrigerating Engineers, the Constitution and By-Laws, a list of members, an index to the papers printed in the several volumes of our Transactions and a membership application blank, all neatly inclosed in a cover on which was embossed the emblem of the Society.

The usefulness of this Society largely depends on the extent of its membership and the Council urges every member to see that every one engaged in the industry qualified to be included in its membership becomes a member of the Society. We have many important duties to perform and a large membership goes a long way toward the success of any undertaking we may attempt.

As a slight evidence of the interest the membership takes in the meetings and work of the Society, it might interest the membership as a whole to know that late in the afternoon of the day our recent meeting was held in Chicago it was proposed to give all delegates to the Third International Congress of Refrigeration an automobile ride about the boulevards of Chicago and it was unanimously voted to continue in session instead of taking the automobile ride.

The Society's contribution to the Third International Congress of Refrigeration Fund amounted to $205.25.

Respectfully submitted,

(Signed) PETER NEFF, *President.*

Under Unfinished Business President Neff first called for a report from the Cold Storage Legislation Committee. Henry Torrance, Jr., New York, N. Y., chairman of this committee, reported that there had been practically no activity along this line in the various state legislatures and Congress, and the committee had not been called on to do any work during the past year.

Henry Torrance, Jr., reported that the Deficit Fund Committee had collected to date a total of $1,526.50. He further reported that additional contributions were expected.

The Fifth National Conservation Congress Committee, through its chairman, W. M. Chatard, Baltimore, Md., reported that members of the committee had attended several sessions of the Congress but that nothing of special interest to the Society came before the Congress.

A motion prevailed authorizing the President to appoint a Resolutions Committee, and he appointed J. F. Nickerson, Chicago, Ill.; Theodore Kolischer, Philadelphia, Pa., and Homer McDaniel, Cleveland, O., on this committee.

President Neff brought to the attention of the meeting the following letter from Dr. S. W. Stratton, Director of the Bureau of Standards, Washington, D. C.:

DEPARTMENT OF COMMERCE,
BUREAU OF STANDARDS.

WASHINGTON, D. C., November 19. 1913.

MR. PETER NEFF,
Canton, Ohio.

DEAR SIR:—In reply to your letter of October 13, relative to the work of the past year on refrigeration constants, the Bureau is pleased to write as follows:

In accordance with plans decided upon at a conference between members of your committee and representatives of the Bureau of Standards during November, 1912, the first problem undertaken was a determination of the heat of fusion of ice This work has been completed, the results presented at the Third International Congress of Refrigeration, and the full report is now in process of publication.

In connection with this work it was deemed desirable to determine the specific heat and the thermal expansion of ice. The necessary apparatus for the specific heat measurements has been completed and is being calibrated for use. The apparatus for the co-efficient of thermal expansion is being constructed.

Other work in progress and completed may be outlined as follows:

Heat of Vaporization of Anyhdrous Ammonia.—Two experimental methods have been laid out and the apparatus necessary for determinations by one method has been constructed. Preliminary experiments have been made to determine the best design for apparatus to be used for determinations by the second method.

Specific Heat of Liquid Anhydrous Ammonia.—The apparatus prepared for the latent heat work was constructed so as to be used with slight modifications for this problem.

Specific Heat of the Vapor.—Apparatus has been nearly completed for use in this problem.

Vapor Pressures.—A rather elaborate and accurate standard open mercury manometer with a capacity of fifteen atmospheres, has been constructed. Also an auxiliary manometer has been built, which should permit of accurate pressure measurements up to sixty atmospheres. Other apparatus for this problem is partly prepared.

Density of Aqua Ammonia Solutions.—The required apparatus is about two-thirds completed.

In addition to the design and construction of the apparatus referred to, a carbon dioxide compression system has been installed for use in controlling the temperatures of the various comparison baths required for use in these investigations. This has offered unexpected difficulties and has caused much delay, chiefly due to leaks which developed in the lines of piping which run some seven hundred feet through tunnels, in many places rather difficult of access. The system now seems to be satisfactory.

The work of the year beginning in July, 1912, was delayed on account of the late date at which the special appropriation became available. As much preliminary planning had to be done and considerable special apparatus constructed, it was found desirable to purchase a supply of apparatus

and materials during the year, in order to leave most of the appropriation for the next, or present year available for salaries, when more help could be used advantageously.

All the apparatus referred to above has been designed with a view to its use in determining the constants of substances other than ammonia, in particular of carbon dioxide, ethyl chloride, methyl chloride and sulphur dioxide. Work upon these substances will follow as time permits.

In addition to the above, some preliminary work has been under way with a view to developing methods of measuring the thermal conductivity of some insulating materials. This is being carried on as time will permit, and can not be expected to yield results for some time to come.

Taken all together, the work of the past year has been largely in preparation for the experimental determinations which are now being started. Although it is impossible to predict what delays may arise from unforeseen experimental difficulties, it may be expected that the work from now on will be more along the line of direct experimentation.

Respectfully,

(Signed) S. W. STRATTON, *Director.*

A motion prevailed authorizing the appointment of a committee to confer with the Bureau of Standards in its work on refrigerating problems, and President Neff left the appointing of this committee to the incoming president.

Several invitations were now presented from San Francisco commercial organizations, etc., inviting the Society to hold a meeting in San Francisco in 1915, as well as the invitation of the engineering societies co-operating in holding the International Engineering Congress, which will be held in San Francisco in September, 1915, and President Neff asked an expression from the membership to guide the Council in acting on these invitations. It was the concensus of opinion that the Society should hold a meeting in San Francisco at that time, especially as a meeting is to be held in the West in 1915. It was also decided advisable that a letter be sent to the membership at large requesting an expression of opinion as to holding a meeting in San Francisco in 1915.

The amendments to Section C 17 of the Constitution, introduced by the Council at the Eighth Annual Meeting, were now taken up for final discussion and approval or rejection. Section C 17 of the Constitution follows, and the words in Italics indicate new matter to be substituted for the words in small capitals in parentheses immediately following:

INITIATION FEES AND DUES

C 17. The initiation fee for membership shall be as follows:
For Members and Associates, five dollars.

For Juniors, five dollars.

A Junior on promotion to any other grade of membership shall pay an additional fee of five dollars.

The annual dues for membership shall be as follows.

For Members and Associates, *fifteen* (TEN) dollars.

For Juniors, *ten* (FIVE) dollars, for the first six years of their membership, and thereafter the same as for a Member or Associate.

The amendments were unanimously approved.

A discussion now prevailed as to changing the time of holding our annual meetings from the Monday preceding the first Tuesday in December to the Tuesday preceding the first Wednesday in December, and at the same time changing the holding of our business session from the first session to the last session of the meeting. The Secretary told of a movement under way by the secretaries of the various engineering organizations to readjust the meeting dates of the various organizations so that they would not conflict with each other, and suggested that any change in meeting dates might be deferred until the secretaries of the various organizations had made a report. A motion prevailed leaving the matter to the Council for consideration.

The report of the Tellers of Election of Officers was next in order. It follows:

REPORT OF TELLERS OF ELECTION OF OFFICERS

NEW YORK, N. Y., December 1, 1913.

MR. PETER NEFF, President,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York, N. Y.

DEAR SIR:—The undersigned Tellers of Election of Officers beg to report that we have canvassed the ballots for officers for the offices falling vacant after this, the ninth annual, meeting and further report that 127 ballots were cast, four of which were void. The vote was as follows:

FOR PRESIDENT

Henry Torrance, Jr., New York, N. Y.	122
Theodore O. Vilter, Milwaukee, Wis.	1

FOR VICE-PRESIDENT

Theodore O. Vilter, Milwaukee, Wis.	122
Edward F. Miller, Boston, Mass.	1

FOR TREASURER

George A. Horne, New York, N. Y.	123

FOR DIRECTORS

A. P. Criswell, Chicago, Ill.	122
John S. DeHart, Jr., Newark, N. J.	122
Van R. H. Greene, New York, N. Y.	121
F. E. Matthews, Leonia, N. J.	120
Edward F. Miller, Boston, Mass.	121
L. Howard Jenks, New York, N. Y.	1
W. S. Shipley, New York, N. Y.	1

We therefore find that the following have been elected to the offices indicated:

President—Henry Torrance, Jr.
Vice-President—Theodore O. Vilter.
Treasurer—George A. Horne.
Directors—
A. P. Criswell.
John S. DeHart, Jr.
Van R. H. Greene.
F. E. Matthews.
Edward F. Miller.

Respectfully submitted,

(Signed) HENRY VOGT, A. W. STERRETT, JOHN N. BRIGGS, *Tellers of Election of Officers.*

President Neff appointed Edward N. Friedmann, New York, N. Y., and Theodore O. Kolischer, Philadelphia, Pa., to escort President-elect Torrance to the platform.

In accepting the presidency Mr. Torrance said:

"I think the past Presidents of this Society have done a great deal of good work and have been very ably assisted by Secretary Ross, who has been working with us for many years. He was one of the charter members of this Society and I have always felt that it was due to him that the Society was started; I know it was not due to me, although I was mixed up in it at the time. I observe that we have a larger room this year than we have ever had in the past, this is significant. We must not forget that the intelligence for the work of the Society rests in the general membership and it is up to the members to promote the interests of the Society in every way we can, and I hope the Society will continue to improve in the future as it has done in the past. I thank you for the honor you have conferred on me."

The address of President Neff was the next order of business. His remarks were closely followed and generously applauded.

The session now adjourned for luncheon in the Engineers' Club, as arranged by the Program Committee.

Second Session, Monday Afternoon, December 1

The second session was called to order at 1:30 o'clock P. M.

The papers presented at this session were "The Sterilization of Water by Ultra-Violet Rays," by Max von Recklinghausen, Strassburg, Germany; "The Refrigerator Car—Retrospective and Prospective," by Eugene F. McPike, Chicago, Ill.; "The Refrigerator Car—Retrospective and Prospective," by J. H. Bracken, Chicago, Ill., and "Chemistry of Raw Water Can Ice," by John C. Sparks, New York, N. Y.

A vote of thanks was extended Mr. von Recklinghausen for his very valuable paper.

The session then adjourned.

Third Session, Monday Evening, December 1

The third session of the meeting was called to order at 8 o'clock P. M.

The papers presented at this session were "Electricity for Ice Making and Refrigeration as Supplied by the Central Station," by C. H. Stevens, Brooklyn, N. Y., and "Fruits—Their Handling and Storage," by J. L. Hughes, North Yakima, Wash.

F. N. Speller, Pittsburgh, Pa., gave a lecture on "The Manufacture of Pipe from Ore to the Finished Product," which was illustrated by several reels of moving pictures.

A vote of thanks was extended Mr. Speller for his very interesting lecture.

The session then adjourned.

Fourth Session, Tuesday Evening, December 2

The fourth and final session of the meeting was called to order at 9:30 o'clock A. M.

The papers presented at this session were "A Review of the Feed Systems of Refrigerating Coils and Their Respective Advantages," by Ernst S. H. Baars, Milwaukee, Wis.; "The Saturatic Cycle of Compression," by J. C. Bertsch, New York, N. Y., and "Defining the Heat Conductivity of Insulators," by Charles H. Herter, New York, N. Y.

During the discussion of Mr. Herter's paper a motion prevailed authorizing the appointment of a committee to suggest methods of and promote the testing of the heat transmission of insulating materials. President Neff left the appointing of this committee to the incoming president, as well as a committee to determine the sources of foreign gases in refrigerating systems.

The topic "Ammonia Purifiers or Regenerators and Foreign Gases in Refrigerating Systems" was discussed at this session.

The report of the Resolutions Committee was now received. It follows:

REPORT OF THE RESOLUTIONS COMMITTEE

Your committee have the sad duty of reporting the deaths of three members which occurred during the present year:

Edgar Penney
Albert J. Golden
David E. Haire

In the death of Edgar Penney, vice-president and general manager of the Newburgh Ice Machine & Engine Co., Newburgh, N. Y., this Society

has sustained a loss of a charter member and one of its past presidents, who from the inception of the Society gave of his time and talent most liberally for the promotion and advancement of the organization. His character was such that it lent dignity to all his efforts, which redounded to the benefit of his fellow members.

The death of Albert J. Golden, manager of the Industrial Cold Storage & Warehouse Co., Philadelphia, Pa., has removed from the ranks of his associates a highly respected member who was much interested in the work and success of the Society.

A telegram just received announces the death of David E. Haire, consulting engineer, Philadelphia, Pa. Mr. Haire's death is a distinct loss to the Society and to the profession. He was always an active and enthusiastic worker, and helpful in the upbuilding of the organization.

Therefore, be it resolved, that this Society express its appreciation of the loss the industry has sustained in the death of these three men, and take this occasion to pay tribute to the memory of those who are gone, and that the Society extends its sincere sympathy to the relatives and associates of the deceased.

Be it further resolved, that this memorial be spread upon the minutes of the Society and a copy of the same be sent to the families of the departed.

THEODORE KOLISCHER,
HOMER MCDANIEL,
J. F. NICKERSON,
Resolutions Committee.

The following invitation from Arthur Williams, president of The Museum of Safety, inviting the participation of the Society in the International Conference of Safety and Sanitation, was brought to the attention of the meeting by President Neff:

THE AMERICAN MUSEUM OF SAFETY
29 West Thirty-ninth Street
New York, N. Y.

NOVEMBER 20, 1913.

MR. W. H. ROSS, Secretary,
The American Society of Refrigerating Engineers,
154 Nassau Street, New York City.

DEAR SIR:—The Directors of The American Museum of Safety extend to The American Society of Refrigerating Engineers a cordial invitation to take part in the International Conference of Safety and Sanitation which will be held in New York City, December 10 to 12, under the auspices of the Museum.

Companies from different parts of the United States and Europe have already signified their intention of sending one or more delegates to the Conference and it is the hope of the Directors to assemble a large representation from many of our great companies.

The subjects to be discussed are of vital importance to every person closely associated with the organization and upkeep of large industries or deeply concerned in the realization of industrial ideals.

This assertion is substantiated by the active co-operation of men and women of national reputation such as George B. Cortelyou, John H. Patterson, Miss Jane Adams and Mrs. August Belmont.

Industrial conditions will be considered from the viewpoints of workers, employers and the public, as well as of hygiene, health and progress.

The following list of topics for discussion will serve as a general outline of the work planned: "Human Values," Mr. Don C. Seitz, Manager of the New York World; "Safer Shops," Dr. William H. Tolman, Director of The American Museum of Safety; Industrial Plants, Their Equipments and Surroundings," Mr. Frank A. Wallis; "Feeding of Workers," Mr. L. H. Brittain, General Electric Company; "Examination of Employees," Dr. Charles W. Worden, Chief of the Medical Staff of John Wanamaker; "Occupational Diseases," Dr. Alice Hamilton, of Hull House, Chicago; "Factory Lighting," Representative of the Society of Illuminating Engineering; "Ventilation," Dr. C. T. Graham Rogers; "Dental Hygiene," Dr. Homer C. Brown; "Self Control and the School Child," Dr. Gustave Straubenmuller, Associate City Superintendent of Schools.

At the banquet and annual meeting of The American Museum of Safety to be held during the conference the E. H. Harriman Memorial Medal will be awarded for the first time, together with the annual medals of The American Museum of Safety, consisting of the Scientific American, Travelers', Seaman and Rathenau Medals.

The E. H. Harriman Memorial Medal will be awarded to the railroad which has been most successful in protecting the lives and health of its employees and of the public, and it is interesting to remember that the competing railroads extend over the country in every direction and cover more than a billion miles.

We wish to urge you again to send delegates to the conference from every large plant or factory in which you are interested as we feel sure that the resulting stimulus to methods will be reffected in improved conditions and a broader point in view.

May we offer our services to assist you in making arrangements for your delegates.

Very truly yours,

(Signed) ARTHUR WILLIAMS, *President*

A motion prevailed instructing the President to appoint a committee to represent the Society at the International Conference of Safety and Sanitation. President Neff left the appointing of this committee to President-elect Torrance.

A hearty and unanimous vote of thanks was extended to President Neff for the exceptional and able manner in which he had conducted the affairs of the Society during his term of office.

The meeting then adjourned.

W. H. Ross, *Secretary.*

LIST OF MEMBERS AND GUESTS ATTENDING NINTH ANNUAL MEETING

Armstrong, Charles G., New York, N. Y.
Bavier, Robert N., New York, N. Y.
Bertsch, J. C., New York, N. Y.
Binzel, Jr., Peter, New York, N. Y.
Block, Louis, New York, N. Y.
Bonner, William T., New York, N. Y.
Borgstedt, H., New York, N. Y.
Bose, Edward, New York, N. Y.
Bower, W. H., Philadelphia, Pa.
Bozardt, L. B., New York, N. Y.
Bridgette, R. E., Brooklyn, N. Y.
Briggs, J. N., Coeymans, N. Y.
Brownell, C. H., Washington Court House, O.
Burch, Jr., T. H., New York, N. Y.
Burhorn, Edwin, New York, N. Y.
Byrne, F. J., New York, N. Y.
Caldwell, O. H., New York, N. Y.
Campbell, Dr. William, New York, N. Y.
Clark, H. E. P., Philadelphia, Pa.
Crawford, Jr., Gilbert H., Philadelphia, Pa.
Cross, D. A., Brooklyn, N. Y.
Dannenbaum, Hermann, Philadelphia, Pa.
Day, A., Bloomfield, N. Y.
Dickinson, H. C., Washington, D. C.
Dodson, Bruce, Kansas City, Mo.
Donkel, William J., Jersey City, N. J.
Dunning, George A. Philadelphia, Pa.
Eadie, Leslie B., New York, N. Y.
Edwards, H. M., New York, N. Y.
Elfers, George, New York, N. Y.
Ely, James, New York, N. Y.
Engel, Henry J., New York, N. Y.
Fairbanks, F. L., Boston, Mass.
Fitzsimmons, J. E., New York, N. Y.
Flack, J. Day, New York, N. Y.
Forgy, J. E. Wilmington, Del.
Friedmann, E. N., New York, N. Y.
Gaiser, J. A., New York, N. Y.
Greene, Van R. H., New York, N. Y.
Griffiths, K. F., New York, N. Y.
Hall, R. M., New York, N. Y.
Hardy, S. J., New York, N. Y.
Hargreaves, William, New York, N. Y.
Hepke, George A., New York, N. Y.
Herter, Charles H., New York, N. Y.
Hill, J., New York, N. Y.
Hoffmann, W. John, Brooklyn, N. Y.
Hoos, William, Philadelphia, Pa.
Horne, George A., New York, N. Y.
Howe, Arthur E., Philadelphia, Pa.
Howell, H. P., New York, N. Y.
Humes, James, Philadelphia, Pa.
Irwin, B., Brooklyn, N. Y.
Irwin, O. C., Canton, O.
Irwin, Robert V., New York, N. Y.
Jenks, L. H., New York, N. Y.
Joyce, Jr., J. B., Jersey City, N. J.
Judson, H. H., New York, N. Y.
Kehoe, Robert P., New York N. Y.
Kellegrew, F. W., New York, N. Y.
King, John D., New York, N. Y.
Koenig, H. H., New York, N. Y.
Kolischer, Theodore, Philadelphia, Pa.
Krieger, Charles J., New York, N. Y.
Langdon, G. M., New York, N. Y.
Lawrence, J. H., New York, N. Y.
Lewis, L. L., New York, N. Y.
Lewis, W. J., New York, N. Y.
Luide, F. P., New York, N. Y.
Lyle, J. I., New York, N. Y.
McCandlish, R. M., Kansas City, Mo.
McDaniel, Homer, Cleveland, O.
Magee, W. H., Boston, Mass.
Marks, Linonel S., Cambridge,, Mass.
Marshall, A. T., Hartford, Conn.
Marshall, H. H., Hartford, Conn.
Matthews, F. E., Leonia, N. J.
May, Walter J., New York, N. Y.
Miller, H. T., Boston, Mass.

Monks, W. D., New York, N. Y.
Moore, W. J., New York, N. Y.
Morse, John S., New York, N. Y.
Morse, Louis S., York, Pa.
Morton, William P., Philadelphia, Pa.
Narath, W. G., New York, N. Y.
Neeson, C. R., New York, N. Y.
Neff, Peter, Canton, O.
Neubecker, J., New York, N. Y
Newbery, T. G., Philadelphia, Pa.
Newham, H. S., New York, N. Y.
Nickerson, J. F., Chicago, Ill.
Nicol, George A., New York, N. Y.
Nolde, Fred, New York, N. Y.
Norwood, H. Y., Rochester, N. Y.
Orrok, Albert H., New York, N. Y.
Palmer, C. C., New York, N. Y.
Petersen, Samuel, Philadelphia, Pa.
Plock, John L., New York, N. Y.
Porter, H. W., New York, N. Y.
Price, William T., New York, N. Y.
Ramsey, L. A., New York, N. Y.
Rankin, T. L., Sackett Harbor, N. Y.
Reilly, J. P., New York, N. Y.
Rice, J., New York, N. Y.
Richmond, H., New York, N. Y.
Rider, H. N., Lorain, O.
Roland, C. F., New York, N. Y.
Root, William A., New York, N. Y.
Ross, A. C., New York, N. Y.
Ross, W. H., New York, N. Y.
Russell, F. S., Chicago, Ill.
Scott, E. A., New York, N. Y.
Shipley, R. T., New York, N. Y.
Shipley, W. S., New York, N. Y.
Shipman, R. L., Ithaca, N. Y.
Sigerson, E. B., New York, N. Y.
Simonton, I. B., New York, N. Y.
Smith, Guy B., Brooklyn, N. Y.
Smith, Herbert E., Boston, Mass.
Sparks, John C., New York, N. Y.
Speller, F. A., Pittsburgh, Pa.
Stagg, J. C., New York, N. Y.
Starr, John E., New York, N. Y.
Sterrett, A. W., Tacoma, Wash.
Stevens, C. H., Brooklyn, N. Y.
Stevenson, S. P., Chester, Pa.
Sutton, W. S., New York, N. Y.
Syckelmoore, George H., Philadelphia, Pa.
Thayer, L. O., New York, N. Y.
Thomson, George W., New York, N. Y.
Thompson, Charles B., New York, N. Y.
Tickle, Arthur, Brooklyn, N. Y.
Toohey, M. A., Newark, N. J.
Torrance, Jr., Henry, New York, N. Y.
Usher, George C., New York, N. Y.
Vesterdahl, Karl, New York, N. Y.
Vogt, Henry, Louisville, Ky.
von Recklinghausen, Max, Paris, France
Waite, N. J., Cleveland, O.
Wallis, George E., New York, N. Y.
Webber, W. J., Boston, Mass.
Wegemann, Karl, New York, N. Y.
Weisenbach, F. A., Philadelphia, Pa.
Wheeler, G. H., New Brunswick, N. J.
Widmann, F., St. Louis, Mo.
Wills, W. H., New York, N. Y.
Wilson T., New York, N. Y.
Wittel, A., New York, N. Y.
Wood, Harold B., Hudson, N. Y.
Young, C. H., Pittsburgh, Pa.

THE BANQUET

On the evening of Tuesday, December 2, the members found both relaxation and enjoyment in an informal, old fashioned beefsteak dinner at Healy's on Columbus avenue at Sixty-sixth street, New York City. About 100 members and guests enjoyed the occasion.

John E. Starr, New York, N. Y., acted as toastmaster and

addresses were made by President-elect Henry Torrance, Jr., New York, N. Y.; Ex-President Peter Neff, Canton, O.; A. W. Sterrett, Tacoma, Wash.; R. M. McCandlish, Kansas City, Mo.; Henry Vogt, Louisville, Ky.; H. C. Dickinson, Washington, D. C.; John Hill, New York, N. Y.; James Ely, New York, N. Y., and L. Howard Jenks, New York, N. Y.

MEMBERS AND GUESTS ATTENDING BANQUET

Bertsch, J. C., New York, N. Y.
Binzel, Jr., Peter, New York, N. Y.
Block, Louis, New York, N. Y.
Borgstedt, H., Yonkers, N. Y.
Bower, W. H., Philadelphia, Pa.
Bozardt, Leon B., New York, N. Y.
Bridgette, R. E, Brooklyn, N Y
Briggs J. N., Coeymans, N. Y.
Byrne, F. J., New York, N. Y.
Crawford, Jr., Gilbert,
Washington, D. C.
Dickinson, H. C., Washington, D. C.
Dodson, Bruce, Kansas City, Mo.
Edwards, H. M., New York, N. Y.
Ely, James, New York, N. Y.
Engel, H. J., New York, N. Y.
Fitzsimmons, J. E., New York, N. Y.
Greene, Van R. H., New York, N. Y.
Hill, J., New York, N. Y.
Hoffmann, W. John, Hoboken, N. J.
Howe, Arthur E., Philadelphia, Pa.
Howell, H. E., New York, N. Y.
Irwin, Robert V., New York, N. Y.
Jenks, L. Howard, New York, N. Y.
Judson, E. H., New York, N. Y.
Kellegrew, F. W., New York, N. Y.
Lewis, Jr., W. J., New York, N. Y.
Lyle, J. I., New York, N. Y.
McCandlish, R. M.,
Kansas City, Mo.
Magee, W. H., Boston, Mass.
Marshall, A. T., Hartford, Conn.
Marshall, Henry H., Hartford, Conn.
Monks, W. D. New York, N. Y.
Neff, Peter, Canton, Ohio.
Neeson, C. R., New York, N. Y.
Newbery, T. G., Philadelphia, Pa.
Nickerson, J. F., Chicago, Ill.
Nolde, Fred, New York, N. Y.
Orrok, Albert H., New York, N. Y.
Porter, H. W., New York, N. Y.
Ramsey, L. A., New York, N. Y.
Reilly, J. P., New York, N. Y.
Richmond, H., New York, N. Y.
Ross, A. C., New York, N. Y.
Ross, W. H., New York, N. Y.
Shipley, W. S., New York, N. Y.
Smith, Guy B., Brooklyn, N. Y.
Stagg, J. C., New York, N. Y.
Starr, John E., New York, N. Y.
Sterrett, A. W., Tacoma, Wash.
Stevenson, S. P., Chester, Pa.
Syckelmoore, George H.,
Philadelphia, Pa.
Sutton, W. S., New York, N. Y.
Thomson, George H.,
New York, N. Y.
Tickle, Arthur, Brooklyn, N. Y.
Torrance, Jr., Henry,
New York, N. Y.
Vogt, Henry, Louisville, Ky.
Wallis, George E., New York, N. Y.
Wegemann, Karl, New York, N. Y.
Weisenbach, Fred A.,
Philadelphia, Pa.
Wheeler, G. H.,
New Brunswick, N. J.
Wilson, T., New York, N. Y.
Wood, Harold B., Hudson, N. Y.

PAPERS

OF THE

NINTH ANNUAL MEETING

NEW YORK, N. Y., DECEMBER 1 AND 2, 1913

No. 116

PRESIDENTIAL ADDRESS

By Peter Neff, Canton, Ohio

The long anticipated meeting in this country of the International Congress of Refrigeration has passed into history.

To those who were able to attend, there was a broadening of the view-point and a stimulus which only such gatherings can give. It marks an epoch in our industry and there should be some lessons drawn from it, for, unless there are, of what avail all the energy, time and money expended.

Time alone can reveal how far reaching shall be the influence which it exerted, but something there must be of vital interest to this organization, representing, as it does, a body of men most deeply interested in the problems of refrigeration.

Many of you will read all the papers, some will be content with the reviews which will appear, and some perhaps may be so engrossed in their daily work as to miss entirely at least the collateral knowledge which the reading of the papers must of necessity give.

There is one fact which the members of this organization should take seriously to heart; that is, that others are investigating the problems of refrigeration, bringing forth suggestions and paving the way for some almost revolutionary ideas and practices.

What we as an organization have to fear is that others will outstrip us, not alone in the knowledge of the subject, but in placing before the world facts and causing us to follow where we should have led. If this organization is to be what its founders contemplated and what we, in our possible arrogance, have believed we were, the leading organization for the promulgation of the truths of refrigeration, it is possible that we may receive shocks which will cause us to realize that we have lost some opportunities.

Have we not been too prone to look on our interest in refrigeration from the stand-point of what it could do to promote our individual good, and this good often confused with material gain,

rather than realize that we were the custodians of knowledge to be applied for the welfare of mankind.

It perhaps has not been vivid enough to us that refrigeration has reached the dignity of being something that is vital to our complex civilization, and that to work out the problems, which such a position demands, requires an altruistic treatment.

We have done much, but have we done all that was to be expected? The answer to this may be one of the lessons to be learned, and it is not too late to profit by it.

Look at what the International Association of Refrigeration is doing through its commissions regarding the unification of the terms and basic constants as used in the art; how they have outlined testing conditions and are going into all that pertains to the industry; read the reports made by Dr. Onnes of Leiden and the papers of Juppont, especially the one "On the Unification of the Values, Units, Terms and Symbols used in the Refrigerating Industry." Their ideas may be right and again they may not appeal to us. Some of these matters came very near reaching a decision at the late Congress, and will undoubtedly be put through at the next. It will be well worth our while to have a committee appointed that will study these questions, if possible secure papers on the subjects for presentation at our meetings, but at least let them keep this Society posted as to what is being attempted. If we find that it is what we want, let us give it our assistance, if it is not, let us protest in time; but do not, I beg of you, permit us to be ignored and compelled to accept their mandates when it is too late to protest.

We have started investigations and allowed others to get the credit. At the present time there is work going on under the Bureau of Standards that should receive our cooperation.

We must make our influence felt and that for good to the greatest number, our view-point must include the world.

A most wonderful development of refrigeration has been built up in this country, but when viewed by the foreigner, with his scientific training and the one object of economy ever before him, how must some of our installations appear to him.

In all the talks, by those who view our industry in the broad sense, the problems of conservation were the ones thought of, and how our art could save waste and destruction, and make for the preservation and cheapening of the necessities of life. We cannot afford to go on as we have in the past, having the accomplishment

of something of more moment than how that accomplishment might be economically attained.

Individually many of our members are doing yeoman service to the industry at large, but this is an age of organized effort; if big things are to be done we must unite to do them.

This Society, as our constitution says, "is to promote the arts and sciences connected with refrigerating engineering." The personnel of our Society is such as to make possible all that our founders hoped for; what we need is good team work to cope with other organizations and show our ability to lead.

To my mind now is one of the critical periods in our history, and I feel that the situation will be met by those having the Society's affairs in charge in the same masterly way as other serious obstacles to our development have been met and overcome.

Prof. Claude, of France, in his lecture on liquid air, which by the way you will find exceedingly interesting reading, refers to what I have been endeavoring to impress upon you when he says: "I cannot really forget that it is in this country that liquid air has made itself talked about before, and in the most intense manner, through the striking experiments of Tripler. And I fear that the realities that I shall have to show you, superb as they are, will appear modest to you before the expectations of Tripler, awakened nearly twenty years ago. Only you know that these expectations have not been realized. It is because they were founded on a misapprehension, nevertheless entirely excusable in such a subject, of the requirements of thermodynamics. And there resulted from this, for liquid air, a disfavor, a discredit, the effects of which, in this country, still make themselves felt, while the industry to which it has given place has made, in Europe, as a result of the labors of Prof. Linde and my own, considerable progress. It has remained here in an embryonic state, a surprising fact for those familiar with the magnificent industrial development of the United States, the genius of its scientists and the superb boldness of its engineers."

Multiple effect compressors and absorption machines; the employment of refrigerating machines for heating; the various methods for steam economies, are some of the sign posts pointing the way to more economical apparatus.

The varied applications of refrigeration to industries, and as helps to scientific determinations, all show that the unsolved prob-

lems are numerous enough to warrant our belief that we are but entering upon what refrigeration can accomplish.

The paper by Dr. Barnes, with the talk by Mr. Murphy, on ice formation, showed how the most tremendous effects can be produced by almost insignificant changes in temperature, when they find that a few thousandths of a degree change is sufficient to cause the stoppage of a large water power plant, and how this same apparently insignificant change in temperature may be corrected so as to prevent the trouble. It is a good paper, and suggests to anyone reading it that possibly in some such small instability may rest the success or failure of some of our processes for ice making.

The Pennsylvania State College is said to have the largest and best equipped thermal testing plant in this country. What help may we hope to have from them on heat transmission? Such an institution needs our cooperation in order that its work may be directed to those problems which we now have so often to figure out and then guess at the results.

Abroad they are encouraging the education of men to become refrigerating engineers, and we should be more active in such work here.

There was much discussion regarding the various types of power to be employed for operating refrigerating machines. The electric companies are looking to us for guidance in working out the problem of the use of electricity from central stations; gas engines, oil engines and improvements in steam engineering are all pressing for authoritative statements. We can not escape our responsibility, it is strictly up to us to say whether this or that is right, we cannot leave it to someone else, who perhaps may have ulterior motives, but who has the ability and push to present the matter attractively.

We are conservative by training and rightly so, but we must not allow that conservatism to become an obstacle to progress. In other words we cannot be merely a passive organization. If we get into this frame of mind we will stagnate. We must be aggressive, we must lay-hold of these problems and, when they are presented by others, we must take them up fearlessly, analyse them, determine their weak points and if there is a spark of merit fan it into flame.

I am too proud of this organization and have too high an appreciation of its ability to criticise it, but I do want, if possible, to

stimulate you as an organization to greater effort, in order that our Society may occupy, without fear of question, the position in the refrigerating industry to which it is justly entitled.

It is no light task to be the president of this body, future presidents will, as those in the past have done, work hard for the upbuilding of the Society, and they will direct the work toward those high ideals that have been always before use, but it is to us, the members, on whom rests the responsibility of whether those ideals shall be achieved.

No. 117

THE STERILIZATION OF WATER BY ULTRA-VIOLET RAYS

By Max von Recklinghausen, Ph. D., Strassburg, Germany

(Non-Member of the Society)

Your Program Committee has asked me to present to your Society a paper on the art of producing sterile drinking water by Ultra-Violet Rays. It gives me a particular pleasure to read such a paper, as I know that there is now in the ice making industry a growing tendency to freeze natural water instead of distilled water. It is a matter of course that in such cases we must make sure that the water before freezing is hygienically safe. This is the more necessary as it is known that water in the frozen state will preserve microbes, the carriers of so many maladies, so that when thawed out they may be as virulent as in their original state. I scarcely need remind you that we count among the diseases spread by water *cholera, typhoid* and *dysentery*.

As there are scarcely any waters constantly bacteriologically above suspicion, it is to be expected that you will adopt methods for rendering the water bacteriologically harmless, that is, it must be sterilized before freezing.

The latest method, and the one I will describe to-day, is the treatment of water by ultra-violet rays. This is really the closest approach to Nature's method of freeing water from germ life, as the sun does the same work on the water of our rivers and lakes. That the work of the sun is due to a great extent to the ultra-violet rays contained in its light is known to us since the research work of Downs and Blunt, Finsen and his pupils, and many other scientific workers. The application of the ultra-violet light for producing sterile water has been advocated repeatedly by De Mare, Lambert and others and has recently been worked out into a really commercial system, following the elaborate research work which I have done jointly with Henri and Helbronner at the Sorbonne University in Paris.

We have given this system the name "R.U.V." from the abbreviation of the Latin name of these rays—*Radii Ultra-Violacei*.

What we have been endeavoring to do is to establish a system that on the one hand produces water which may be relied upon to be sterile, and, on the other hand, water produced in a practical way and so economically that there can exist no good reason to stand in the way of its adoption, even for public water supplies of the largest cities.

It has taken some years of research work to construct apparatus that will permit of the use of the ultra-violet rays to their fullest efficiency and assure perfect sterilization, although the principle of the process seems simple enough, namely, to illuminate the water with the light from an artificial source of ultra-violet rays for a sufficient time to annihilate its microbes.

We have adopted the mercury arc enclosed in quartz containers as the richest industrial source of ultra-violet rays. The mercury arc, like all metal arcs, produces, together with its visible rays, a great amount of invisible rays of shorter wave length than the visible ones, which, being outside the violet part of the spectrum, are called *ultra*-violet rays. The mercury arc is enclosed in a quartz tube, because quartz, that is, fused rock crystal, has so far been found to be the most practical material not opaque to ultra-violet radiations. Glass is, for instance, perfectly opaque to these rays. The hotter we run such a lamp, the more ultra-violet rays it will produce. We are limited only by the fact that, if heated too highly, quartz will deteriorate and become opaque in the long run. We have to maintain, according to our experience, a maximum temperature of about 800 degrees Centigrade to secure a really efficient production of rays and a long life for the lamps.

In the construction of efficient sterilizing apparatus, we have found that we must not interfere with the desired high temperature of the arc by permitting it to come into contact with the water, as this contact would cut down the efficiency to an enormous degree. On the other hand, particularly for water sterilizers that are constructed in view of economical sterilization, it is naturally important to construct the apparatus so as to place the mercury arc close to the water, as near as compatible with the above principle, and to make use, if possible, of all the light emitted by the burner. In smaller apparatus we have decided to sacrifice some of the economy in view of obtaining a handy, simple and light construction.

So much for the adaptation of the light source in the different constructions. We now come to the question of the state in which we have to submit the water to the rays in our apparatus.

We know that water has a great transparency for ultra-violet rays, namely, about as much as air. On the other hand, we know, as I have already mentioned for glass, that, with the exception of quartz, there exists practically no solid material which is transparent to the ultra-violet rays. We must therefore be sure that the water we submit for treatment by our ultra-violet rays sterilizers is free from any solid suspended matter, as such material may form shadows in which the microbes are protected from the bacteriacidal action of the rays. It is easy enough to free water from suspended matter by filtration by well-known devices, and I consider the necessity of having to use clear water for the ultra-violet ray sterilizers an advantage for the water user, because he will be sure to always receive a palatable looking water. However, even the best filters will sometimes allow some microscopic solid matter to pass through into the water, and, although being of a dimension to be nearly transparent to the rays, these particles may nevertheless protect some germs against the rays. We therefore must make sure to throw light on every side of them. This is of the greatest importance, and is done in a simple way by giving the water, while it passes in the rays, a stirring motion or agitation, which will turn over and over again all such small suspended matter. We have determined, experimentally and in practice, that submitting such water to a quiet flow under the light is far less efficient or reliable in its results than submitting the same amount under agitation to the same lamp, bringing the whole body of water several times in contact with the rays of the lamp. We obtain the agitation in all of our apparatus by the flow of the water against baffles, which are so designed as to produce a minimum of shadows in the sterilizing apparatus. The speed of the flow is determined by the specific transparency for the rays of the water which is to be sterilized.

Now as to the construction of our R.U.V. apparatus, I refer first to the design of our B2 hospital type, Fig. 1. A typical test of this apparatus has given the following results:

Speed of flow	Before Treatment— germs per c.c.	After Treatment— germs per c.c.
120 gals. per hour	1040	0.3

Such apparatus is used on a large scale in Europe for producing safe water for drinking and even for surgical purposes. I only mention one particularly interesting application—in a field hospital during the French-Morocco campaign—where the results of its ap

plication was a complete absence of typhoid and wound infection in this hospital during 18 months, except naturally for cases brought in from outside.

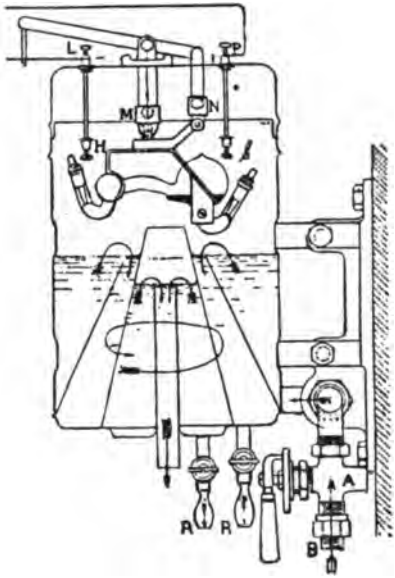

FIGURE 1—B2 TYPE STERILIZER

Figure 2 shows our B5 apparatus which is built for a small output, namely, about 20 gallons an hour. A typical test with this apparatus has shown the following results:

Speed of flow	Before Treatment— germs per c.c.	After Treatment— germs per c.c.
20 gals. per hour	32100	0.2

In the larger type of apparatus, used for municipal water supplies, Fig.3, I first mention the type C3, which sterilizes up to 600 tons of water per day with a 1 HP. lamp. This apparatus passed successfully the official tests of competitive water purification systems, made in Marseilles in 1910, and was the first apparatus of his type installed in Europe and has been in continuous service for three years in Marommes-les-Rouen, France. It has also been introduced in other towns, where in some cases it is used for producing pure water for bottling purposes. A typical test with this apparatus showed a diminution from 1400 to 7 germs per c.c.

FIGURE 2—B5 TYPE STERILIZER

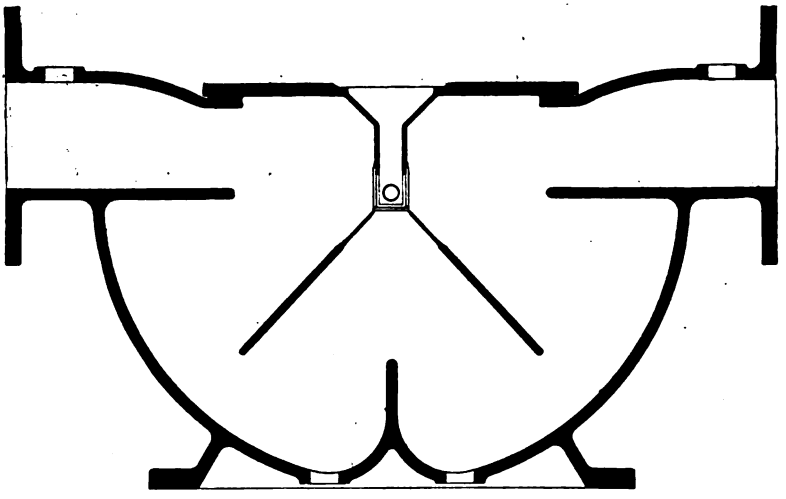

FIGURE 3—C3 TYPE STERILIZER

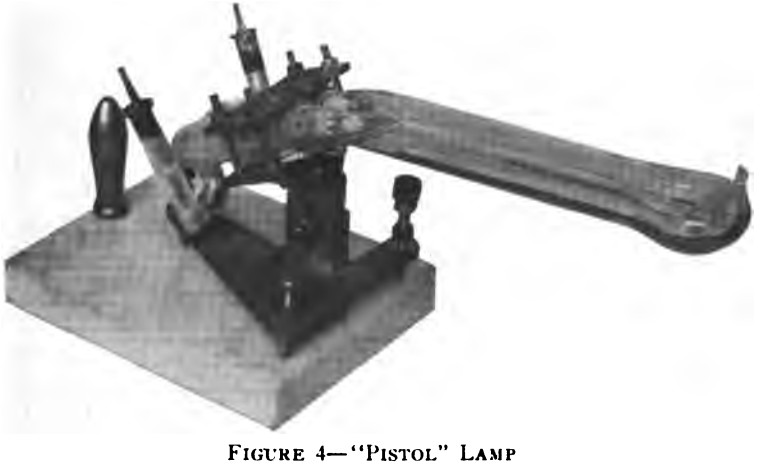

FIGURE 4—"PISTOL" LAMP

Some time ago we developed what we called a "Pistol type burner," Fig. 4. The apparatus constructed to employ these burners is of the highest possible light efficiency, and allows us, by multiply ing the number of burners, to sterilize up to 10,000 tons of water per day in a single unit.

This latest type of apparatus, Fig. 5, is running successfully in several municipal water plants. I mention particularly the installation we made for the city of Luneville, France, where one single apparatus sterilizes 7,500 tons of water per day. This plant has been

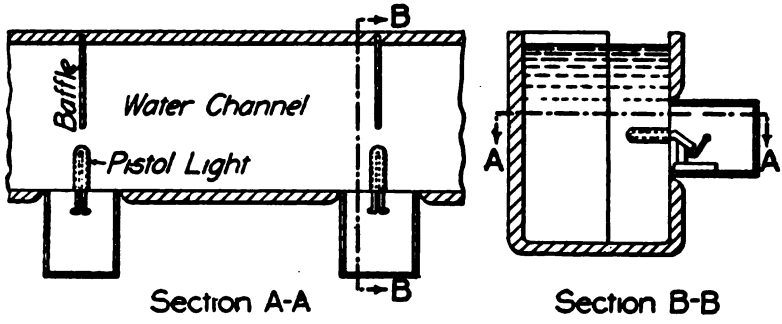

FIGURE 5—STERILIZING TANK WITH "PISTOL" LAMP

running under Government supervision for about one year, and has been accepted by the Government and the city after a long series of tests extending over nearly a year. In this installation the apparatus is fed with heavily polluted river water, which is first filtered over roughing filters and sand filters. Although this apparatus is fitted with twelve 1.5 Kw lamps, there are never more than six in service, using thus only about 9 Kw for the whole sterilizing apparatus treating 7,500 tons of water a day. The raw water contains numerous germs like any polluted river water. After filtration it contains at times as many as 1000 per c.c. The water leaves the sterilizer with rarely more than 10 germs per c.c. and no Coli bacteria, although the filtered water nearly always shows pollution from this bacteria.

The water in all the smaller apparatus is exposed some seconds and in the larger types some minutes to the ultra-violet rays. There is no change produced in the water, as to its contents of salts or gases, by this exposure, that is, the ultra-violet rays do not interfere in any way with any of the desriable qualities of the water or its taste.

DISCUSSION

John C. Sparks.—May I ask the Doctor if there are any installations of this system in this country?

M. von Recklkinghausen.—No, we are only just beginning to introduce it in this country.

John C. Sparks.—Have you worked out any figures as to the cost of treating a definite number of gallons per day?

M. von Recklinghausen.—Oh! yes, for instance, in the case of this Lunéville plant, which sterilizes 7,5co tons of water per day, the consumption is about 30 watt hours per metric ton; the expense depends on the cost of the current. In this case, as in many water works, current is made on the spot. If, for example current costs one cent per kilowatt hour, then they have about 33 tons for a cent.

John C. Sparks.—Seems very cheap.

M. von Recklinghausen.—Yes. That water is particularly dirty before filtration and is not of very best transparenry afterwards, so we have to use a good deal of current. In other plants, like the one in Marseilles we have run, if I remember right, up to 4½ times the speed; using therefore down to one-quarter of the watts used in the case of Lunéville. Purely theoretically there would be very much less power needed if it were not for the question of a slight quantity of microscopic suspended matter which passes through any filter, or the amount of coloring matter which naturally no ordinary filter will keep back.

John C. Sparks.—How about the length of life of those lamps?

M. von Recklinghausen.—The average length of life of the lamps when used in city plants is 3,000 hours and more.

Edward N. Friedmann.—Have you tried to sterilize milk or beer?,

M. von Recklinghausen.—We have, I may say we tried it right at the start of our research work, but after a few months we found that it would be better to confine ourselves to the problems which promised a fairly easy solution and were capable of quicker commercial development. The problem which promised the easiest solution was the treatment of water because the water is transparent to ultra-violet rays; therefore the rays remain effective even after they have penetrated a layer of water of a certain thickness. As to the problems of sterilizing other liquids, we thought the most interesting one was milk. I may say that we have worked

it out in a laboratory way, and are now sure we will be able to produce really sterile milk on a commercial scale in the near future. The experiments on milk are infinitely more complicated, because milk is almost perfectly opaque and must, therefore, be spread out in a layer so thin that the rays will surely go through, otherwise the surface or top layer only will be sterilized, and right beneath the milk remains unsterilized; therefore, it must be spread out so thin that the rays will go right through and sterilize also the other side of the layer. I hope at a later day to tell you more about it.

Edward N. Friedmann.—How about beer?

M. von Recklinghausen.—The same difficulty is found in the case of beer, only to a lesser degree, because beer is considerably more transparent than milk. We have tried to do it and can remove from beer the germs it contains, also the yeast which may be in beer causing that slight fermentation which spoils the beer after some weeks or months, but we have not worked it out in detail. There is another problem which, perhaps, is less interesting in this country, but on which I spent a certain amount of energy, and that is the problem of the champagne industry. France, as you know, is a big champagne producing country. The champagne, after the first fermentation, must be stored for about three years in bottles held upside down, and during this long time, practically nothing happens, but the yeast in the champagne gradually sinks down to the bottom of the bottle, on top of the cork, and after three years that cork is taken out, just for a very short time, thereby the deposit is flushed away, and the champagne bottle is closed up again and is then ready for the market. Just think of the enormous amount of champagne which lies in the cellars during the three years for no purpose but to let the yeast slip down. The champagne makers are anxious to shorten that time, and one is attempting, in conjunction with us, to sterilize the champagne right after the first fermentation has taken place, but the experiments are not yet finished.

Edward N. Friedmann.—Can you sterilize anything in a glass bottle?

M. von Recklinghausen.—No, because to ultra-violet rays glass is practically as opaque as stone or metal. Some people have expected from these rays such mysterious effects as, unfortunately, were found peculiar to Roentgen rays. It will be remembered that when Roentgen rays were first applied, some awful cancers developed,

and deaths even occurred as results of their unguarded use. But in case of the ultra-violet rays we are certain that there is no mysterious effect, because as soon as anything opaque to the ultra-violet rays is placed between the observer and the lamp no effect is possible. Hence, in the application of ultra-violet rays there is no more mystery left than there is in the production of light or in an arc lamp phenomenon. There is a possibility of ultra-violet rays going through water, alcohol and some other substances but glass resists the rays, except for a certain slight amount, and that amount is perfectly harmless, because the wave lengths are the same as of the ultra-violet rays emanating from the sun. Those do us little harm, we can protect ourselves easily by wearing ordinary glasses. Our skin is sensitive to ultra-violet rays; you all have had sunburns, which can be ascribed to the ultra-violet rays contained in sun light.

Henry Torrance, Jr.—Are those the result of boiling mercury?

M. von Recklinghausen.—If we throw the spectrum of the sun on to a screen, we find the visible rays, red, yellow, green, blue, and we know there are others; we don't see them with our naked eye, but we can show them with fluorescence on a photographic plate or something like that; the sun's rays go down to certain wave lengths, and the mercury goes very much further down in wave length. The subject of the ultra-violet rays is a very interesting one and is still being investigated by scientists.

Louis Block.—Is Finsen the discoverer of the ultra-violet rays or was his discovery confined to their use for the cure of lupus?

M. von Recklinghausen.—If I remember rightly, the ultra-violet rays were found long ago, about 1806, by Ritter. Finsen was the first to notice the effect of an electric arc in skin diseases. In his laboratory he analyzed the phenomenon and found the effect was due to the ultra-violet rays continued in the lights he happened to use; then he worked out which arc would be best for this use. In 1890 the arc between the iron electrodes was the only one that could be had. He used that and examined carefully its effect on microbes. The whole question of the bacteriological effect of ultra-violet rays has been settled by Finsen and his school. His investigations are far too little known; because his writings were published in a special publication of the Finsen Institute of Copenhagen and have not appeared in any of the other scientific papers.

Louis Block.—There was a party over here who demonstrated

the effects to us and wanted me to drink Schuylkill river water, but I refused.

Theodore Kolischer.—Was that sterilized by ozonation?

M. von Recklinghausen.—Of course, there are a good many ways to sterilize water.

Louis Block.—The method was one used in Holland.

M. von Recklinghausen.—There are plants using oxidizing chemicals and ozone for sterilizing, but none have the simplicity of the mere illumination of the water.

Theodore Kolischer.—Suppose such a method were employed in the manufacture of ice by the raw water system, would it have any influence on the transparency of the water? If not clear, would it make the water clearer?

M. von Recklinghausen.—No, it would have no effect whatsoever on the transparency of the water with a few minutes or even hours exposure. Only the microbes floating in the water are killed. After many hours exposure a very slight bleaching effect is obtained, the water appears to be somewhat clearer, but for ice making the plan is not economical enough for practical application.

Theodore Kolischer.—At how low temperatures can bacteria still live in ice?

M. von Recklinghausen.—There does not seem to be any temperature low enough to kill all bacteria.

John C. Sparks.—Isn't there a time factor?

M. von Recklinghausen.—Perhaps so, in the course of years.

John C. Sparks.—In ice there is a very definite time factor.

Louis Block.—Some bacteria are killed by certain temperatures.

M. von Recklinghausen.—Some bacteria live and propogate at a certain temperature in a preferred medium, while in another medium at another temperature they do not. If water is heated under 15 pounds pressure for twenty minutes, we know there is nothing left, practically, but with lower temperatures and shorter times, every microbe has a different resistance.

John C. Sparks.—Different strains of the same bacteria have different powers of resistance.

M. von Recklinghausen.—Oh! yes, and then it is a question of the age of the culture and all those things. It is a very complicated

problem. What we try to do with ultra-violet rays is to do away with all of them.

John C. Sparks.—As to clearness of water, the treatment would have the beneficial effect of making filtering unnecessary where the water is already clear.

M. von Recklinghausen.—I think that is one of the important factors in your industry.

Edward N. Friedmann.—Have you ever calculated the difference in cost between the ozonizing method and the ultra-violet ray system?

M. von Recklinghausen.—If I had, you might say I am somewhat prejudiced, but I know others have done so. Comparative tests between ozonizing and the ultra-violet rays were made lately at an Italian city water works supplying 50,000 tons of water a day. The tests extended over a period of six months and the ultra-violet rays system proved to be the most advantageous. Ozone is an oxidizer; if you put enough oxidizer in the water, you will undoubtedly sterilize it. It is a question of relative economy in the cost of machinery, skilled attendance, maintenance and reliability.

Theodore Kolischer.—Could you give us an idea of the first cost of a system, such as you showed us, having a capacity of 7,500 tons of water?

M. von Recklinghausen.—I could not say, for I have not gone very much into that question. The cost depends so much on local conditions. For instance, if your water is extremely clear, a given size apparatus may do ten times more than if the water is less clear.

Theodore Kolischer.—For an ice plant of 200 tons capacity a day, the cost would be almost insignificant?

M. von Recklinghausen.—I do not think it would be very great. If people want safety, an arrangement can be made so that, in case the current fails, no untreated water can reach the ice tank. In that case it becomes an engineering problem. Each particular case has to be studied by itself.

John E. Starr.—I have in mind an ice water plant for a hotel, capacity about 2,000 to 2,500 gallons a day; I would like to get some idea of the size of the apparatus.

M. von Recklinghausen.—Offhand, I should say it would take a space about five feet by two by, perhaps, three feet high, and absorb about one horse power.

John E. Starr.—Does it heat the water much?

M. von Recklinghausen.—Not in the least, because the water passes through the apparatus quite rapidly. Physically speaking, there must be a heating of about one-thousandth of a degree—something like that.

President Neff.—Doctor, have you perfected arrangements for the sale of your apparatus in this country?

M. von Recklinghausen.—Yes, the R. U. V. Co., Inc., 50 Broad street, New York, N. Y., is now introducing this system in the United States.

No. 118

THE REFRIGERATOR CAR—RETROSPECTIVE AND PROSPECTIVE

By Eugene F. McPike, Chicago, Ill.

(Associate Member of the Society)

Soon after the close of the Civil War, the American people commenced to reconstruct their fortunes, and as the primary source of wealth is in the soil they redoubled their efforts to wrest a better sustenance from Mother Nature. Many thousands of soldiers released from military duty resumed their normal occupations, among the most important of which was then, as now, the pursuit of agriculture. A great wave of popular interest covered the rural world and gave rise to what has been known as "The Granger Movement," involving numerous co-operative organizations between farmers, for mutual protection and profit. The story of it all forms a very interesting chapter in the history of the United States; a chapter which cannot be neglected by the student of agricultural development, farm credits, or what concerns us all, the cost of living. A very comprehensive review of that field is promised in a work on "The Granger Movement" by Dr. Solon J. Buck of the University of Illinois, to be issued from the Harvard University Press.

About the year 1866 the first twelve large refrigerator boxes for shipping strawberries were constructed by Mr. Parker Earle, then a resident of Cobden, Illinois, for use in forwarding such consignments by express from points in southern Illinois to Chicago, Pittsburg, New York, Memphis and New Orleans. Each box held two hundred quart baskets of berries and one hundred pounds of ice, making a total weight of about six hundred pounds per box when loaded. This method of shipment was fairly satisfactory when the express companies actually re-iced the berries in transit. At times, however, the requisite re-icing service was neglected, owing either to misunderstanding of instructions or possibly to carelessness, and the shipper was obliged finally to abandon the plan. Somewhat larger chests of a similar character were used by steamship lines from Charleston to New York at about the same period. At a later date the small "pony" refrigerator boxes, weighing about one hundred pounds, came into use from Florida.

About 1868 a Mr. Davis of Detroit brought to Cobden an insulated car which was designed for handling beef and fish under refrigeration. This car contained in each corner a vertical cylinder about fifteen inches in diameter, to permit the icing and salting of the car from the roof. This resulted in the freezing of a part of the berries while the remainder were very unequally cooled. The consequent loss discouraged any further ventures of that kind, but like all mistakes it did help toward the ultimate solution, for in the next year a shipper at Cobden secured from one of the eastern railways a car which had been constructed for the transportation of dairy products under ice, and had an ice box at each end with a total capacity of two tons of ice. This car for experimental purposes was loaded with strawberries by the growers at Cobden and forwarded to New York, with a reasonable prospect of reaching that market in good condition, but for the great misfortune that someone in transit removed the plugs from the ice boxes in the roof in order to ventilate the berries and failed to replace the plugs, thus resulting in the very rapid meltage of the ice, and practically all the cargo was destroyed. This had a very discouraging effect, but the shippers in southern Illinois next tried the experiment of building a cooling box in their packing shed so as to hold the berries for twenty-four hours to cool them, before sending them forward by express. This was found to produce fairly satisfactory results, but desiring to make better progress, a refrigerator car of the old Tiffany patent, with V-shaped ice boxes suspended from the roof the full length of the car, was obtained and used for handling berries. The maximum capacity of the ice pan was only one ton and a half of ice, which, of course, was not enough to remove the field heat in a carload of berries, and keep it cool. In the absence of any better facilities the shippers constructed a cooling house sufficiently large to hold ten tons of strawberries, which were cooled down for twenty-four hours and then transferred to a Tiffany car at about fifty degrees Fahrenheit. This brought greater success than any previous efforts and resulted in berries arriving at Chicago in excellent condition. Other cooling houses of similar character were constructed at various points in Southern Illinois for handling berries and other fruits, the successful experiments in this connection dating from about the year 1872.

The shippers in the territory just mentioned, however, felt that there was considerable room for improvement. They wanted a car which would hold at least five tons of ice, so that the fruit could

be immediately loaded therein after picking and be cooled in transit and protected for two or three days. Success finally attended these efforts to secure a well built, well insulated car, with an ice capacity of five tons. The practicability of this system was demonstrated by numerous shipments from various producing points in Mississippi, Florida, Georgia, etc. This aroused the ambition of the shippers, who sought for more worlds to conquer, and going to California succeeded in handling peaches satisfactorily over the long transcontinental haul to Chicago. Such shipments were forwarded daily for a month, greatly to the surprise of the growers and to the trade in general.

In the meantime the growers of fruits and vegetables in the lower Mississippi Valley, of which the fertility is far famed, had succeeded in the shipping of some peaches from points like Crystal Springs, Mississippi, to New Orleans, as the nearest market. These experiments were made in 1866 or 1867 and were soon followed by shipments of pears and plums also to New Orleans. From year to year other farmers in the vicinity engaged in the production of fruits and vegetables for shipment, and in about the year 1877 helped to supply the market in Chicago, Cincinnati and St. Louis, as well as New Orleans. The cultivation of strawberries in the same general territory in about 1875 for shipment to Chicago, Cincinnati and St. Louis, started to a small extent. Until the year 1876 practically all the transportation facilities for these fruits and vegetables in the lower Mississippi Valley was furnished by the express companies, and it was not until 1877, when refrigerator car service from that section was offered by what was then known as the Trans-Continental Transportation Company, who solicited the business at Crystal Springs, Mississippi. Their cars were not very well designed for that traffic, as the ice pans consisted of large overhead troughs running through the cars from end to end, and at first were not boxed in. A somewhat smaller trough was placed under the main trough for the purpose of preventing the dripping water from falling on the lading, but from time to time some unusual motion of the car would cause small pieces of ice to escape from the trough. The railroads at that time had no re-icing facilities of their own in transit, and replenishment of ice, therefore, had to be done by ice dealers at different points en route. This, of course, was in the early days of the service, and at times the car would not be re-iced at the proper interval, thus causing the goods to arrive on the market in bad condition. Some unfortunate experiences of this

kind, coupled with prejudice and the fear of unsatisfactory results, made the growers and commission men slow to avail themselves of the refrigerator car. In a short time the Illinois Central Railroad, leading from the South and having its own rails to the Chicago market, offered to its patrons a refrigerator car service of its own, thus encouraging and fostering the production of fruits and vegetables in that territory.

From these modest beginnings, therefore, has been developed the enormous distribution of fruits and vegetables at least, which has created in the United States in that respect a condition quite unparalleled in any other country of the world. The European centers have for the most part been served by products coming from points within a radius of fifty miles, and to a large extent that is more or less true to-day, with certain notable exceptions. The development of refrigerator transportation in Europe is quite unknown, as we understand it in the United States. A very carefully prepared report presented by Mr. Richard Bloch, Chief Engineer of the Orleans Railway of France, at the Vienna Congress of Refrigeration in 1910, indicated that at that time there was a total of only about 1085 refrigerator cars in Continental Europe, including Russia, Germany and France. In the United States in 1908 the official records indicated about 85,000 refrigerator cars with ice bunkers and about 50,000 other insulated cars without ice bunkers, total 135,000 cars specially equipped for the handling of different classes of perishable products.

Commissioner Lane of the Interstate Commerce Commission, when returning to America after having attended the International Railway Congress in Berne, Switzerland, in July, 1910, stated that the American railroading system is without a parallel in the world because we are living as a nation and in Europe they live as communities. "Our problem is different. We are bringing our bacon from Kansas and from Nebraska and from Texas; our eggs from the west; our fruit from California, Georgia, Florida and Arkansas. The man in the West, 3,000 miles away, is being covered with clothes made in Massachusetts." These remarks about American railroading are not a digression from the subject which we are considering, for they serve to make it clear that the American railroads have unhesitatingly approached and have largely overcome almost insurmountable obstacles. But they must not be expected to perform miracles, for there are certain limitations quite beyond their control and within which they are constrained to

operate. Some unfamiliar with the problem may pretend to think that there is no reason why the railroads should not operate the equivalent of a cold storage warehouse, but there are the impassable limits of size in relation to the clearances en route, over bridges and through tunnels; there are the limitations of weight and the demands of loading space; all necessarily to be considered and which are some of the governing factors. The railway car in America, like the locomotive, is larger than anywhere else in the world. The tendency has been toward increased loads per car, but there are obviously limits to the possible thickness of walls. The most efficient standard to-day calls for three-ply insulation with waterproof floor. Experiments have been made with four-ply insulation, consisting of hair felt or flax fibre, but while this brought, perhaps, a little increase in the conservation of refrigeration, the benefit was relatively so slight as not to justify either the additional expense or weight. The refrigerator car is already heavy, and therefore relatively uneconomical in train haul when used for return transportation with non-perishable goods. There is, of course, considerable divergence of opinion as to the most efficient kind of insulating material to be employed. Cork insulation has not until recently been used in more than a few cars here and there, but now one of the larger railroads has constructed about 1,000 cars in which cork is used for insulation in the flooring and also for a distance of one foot above the top of floor in the sides and ends of car. The reason for using cork in these cars as indicated was not because more efficiency was expected, but was in order to avoid having water carried up into the insulation of car walls and ends by capillary attraction if water should soak through the floor boards or the floor side boards. Those cars insulated with cork have not been subjected to any comparative test under commercial load as against cars with other insulating materials. The water-proofing of refrigerator car floors has also recently been provided for in quite another way.

There are many mechanical problems of one kind or another involved in the construction of refrigerator cars in detail, including the best designs of drip pans, drip cups, bulkheads and screens for same, also ventilating devices and numerous other apparatus, none of which is necessarily of direct interest to the refrigerating engineer or from the standpoint of insulation.

It is not within the scope of this paper, nor have we time to deal with the innumerable inventions and devices relating directly

or indirectly to the refrigerator car. Perhaps the most modern and novel feature of that kind is the collapsible ice bunker, with which several thousand of the newer refrigerator cars have been equipped. This is intended to save between sixteen and seventeen per cent. of the loading space when the ice bunkers are not required, and this might become quite an important item in the case of car shortage, for it could mean sixteen or seventeen extra cars for loading out of every hundred required for current traffic. There are certain shippers who are not strongly inclined to avail themselves of this additional space because their standard loads are based on established practice or because, while their freight may be forwarded without refrigeration, the ice bunkers may be required at a subsequent point en route. There have been a few complaints made against an alleged increase in the cost of maintaining collapsible bunkers as against the stationary bulkhead, but nevertheless the interested lines, according to last advices, are quite satisfied, and under present conditions would probably continue the use of the collapsible bunker in any new cars they may build.

The stationary but open bulkhead equipped with siphon system is in several thousand refrigerator cars today and many people prefer it as against the old solid wooden bulkhead, but the latter also gives good service.

The overhead ice bunker which was used in certain cars many years ago, and which has more recently been adopted in a car receiving some attention by the far northern roads, has certain theoretical advantages because it aids in placing the cold air in the roof of the car where it is needed and where Nature does not easily put it. One objection raised against the overhead tank was the question of counterpoise of the car, particularly when going round a curve, but this difficulty has perhaps been overcome. Another objection is the fact that the overhead tank is very shallow and has six hatch openings in the roof which do not tend to facilitate the re-icing of cars in transit which is an important item owing to the necessity of expediting the movement of trains through the icing stations. Still another objection which has been raised against the overhead tank is the possibility of the drain pipes becoming clogged, thus resulting in the car floor and contents being damaged by water, but it is alleged that the drain pipes are made sufficiently large to prevent clogging. The car in question equipped with overhead tanks also has double floors and double

walls with spaces between to permit the crculation of heat so as to break the frost lines during extremely cold weather in the far North. To this extent the car has some attractions, but there has been considerable hesitation about making that style of car the recognized standard for all classes of business throughout the year in the various sections of the country. In the ordinary refrigerator car, well insulated and with end ice boxes, it is possible for the shippers to place portable false floors upon which to load their goods in the wintertime, and it is also the duty of the shippers of carload freight to pack and wrap if necessary, also so load and stow the freight as to permit of safe transportation to destination. These are duties which under the long-established practice and the standard rules are very clearly resting on the shippers themselves.

The various experiments made with mechanical refrigeration in transit have not been satisfactory either in the United States or Europe. One plan was to have the refrigerating machinery in a car by itself just back of the engine and to pipe the refrigerant to the other cars, but this method, even if otherwise successful, would have the serious objection of provding no means for the continuance of the refrigerating of a car when it might become necessary to set it out from the train in transit because the car was in bad order or for any other reason, such as cars held at destination for unloading or pending reconsignment. The next step was to endeavor to find a mechanical refrigeraton apparatus for each refrigerator car as a separate unit by itself, but any thing of this kind would presumably require the sending of an expert mechanic, if not with each car, at least with each train of perishable freight. This would be an insurmountable objection as it would not be at all practicable for the railroads to adopt any such policy. The suggestion has also been made that liquid air in tanks might eventually be found available for refrigerating in transit, but this is a problem by itself which is not free from peculiar difficulties of its own.

As to prospective improvements in the refrigerator car within the limitations already described, we must bear in mind that the principal desiderata are efficiency and economy, both to the railroad and the shipping public. We can measure the future only by the past, and therefore our further studies must be guided by the light afforded by the design of some of the latest refrigerator cars built and operated by the lines handling an enormous volume

of perishable freight. Let us examine, therefore, the specifications of two such cars, which for convenience may be designated as Car "A" and Car "B":

CAR A.

Gauge	4'- 8½"
Length over sheathing	40'-11⅛"
Length inside of lining	39'-10¾"
Length between ice tanks	33'- 2¾"
Width inside of lining	8'- 2¾"
Height, top of floor to ceiling	7'- 5 3/16"
Total cubic capacity	2,444 cu. ft.
Available cubic capacity between ice tanks.	2,032 cu. ft.
Capacity of both ice tanks	11,000 lbs.
Length over end sills	40'- 9⅝"
Length, inside to inside of coupler knuckles	43'- 9½"
Length over couplers	44'- 3½"
Width over side sills	9'- 1⅛"
Width over sub side sills	9'- 1⅛"
Width over sheathing	9'- 2⅝"
Width over eaves	9'- 6"
Distance, center to center of body bolsters	30'- 8"
Truck wheel base	5'- 6"
Total wheel base	36'- 2"
Height, top of rail to center of couplers	34½"
Height, top of sill to bottom of side plate.	7'-11 13/16"
Height of side door opening	5'- 9⅞"
Width of side door opening	4'- 0"
Height, top of rails to eaves	12'- 3 11/16"
Height, top of rails to top of brake shaft.	13'- 5 13/16"
Height, top of rail to top of running board	13'- 0½"
Light weight of each truck, about	6,066 lbs.
General weight of car complete, about	46,800 lbs.

These cars are equipped with Bettendorf underframe, which is of steel construction throughout. Linofelt insulation is used in the cars, being applied in three ply form, that is, three courses of insulation on top or ceiling, the same on sides, ends and floor of car. The owner finds this to be ample protection from heat or cold.

The collapsible tank is said to be giving entire satisfaction in every respect. The additional loading space obtained by raising

bulkheads figures about 15%. It will be noted from the general description that the total cubic capacity of the car is 2,444 cubic feet, while the available cubic capacity between ice tanks is 2,032 cubic feet, the difference between these figures being about 16.85%. However, the bulkhead, when raised against ceiling, occupies some space, so this figures about 15% as a fair estimate.

The present standard carload of citrus fruit is 396 boxes. As an indication of the loading possibilities of these cars with the bulkheads raised, there was loaded out of California a car containing 468 boxes of oranges and another containing 635 boxes of oranges. Admitting that the latter load is an extreme case, yet, after proper allowance is made therefor, it can be appreciated readily that there is ample space remaining for large increase over the standard load of 396 boxes.

Car B.

INSULATION.

Roof

½" Flax Felt—3 Ply } 3 ply 90 lb. Neponset paper
⅜" Ship Lap—2 Ply } on each side of Flax Felt
⅝" Ceiling

Floor

½" Flax Felt—3 Ply (3 ply 90 lb. Neponset paper, etc.)
1¾" Ship Lap Flooring
⅜" Ship Lap—3 Ply

Sides

13-16" Siding, ⅝" Furring—2 Ply
⅜" Ship Lap
½" Flax Felt—2 Ply (3 ply 90 lb. Neponset paper, etc.)
13-16" Lining

Ends

Same as Sides

Doors

½" Flax Felt, 2 ply inside doors. La Flare patent insulation for door joints.

Hatch Plug

½" Flax Felt, 2 ply, with 3 ply 90 lb. Neponset paper on each side of Flax Felt

Are attached to ventilators and are operated, open and closed, with lever on ventilator

MEASUREMENT.

Tanks Down	Tanks Up
Length—33′ 5¾″	Length—39′ 8¼″
Width—8′ 2¾″	Width—8′ 2¾″
Height—7′ 3″	Height—7′ 3″

ROOF.

Flexible outside metal roof No. 26 gauge galvanized iron.

COLLAPSIBLE ICE TANKS.

Ice box pans and sides 3′ 11″ from floor made of No. 20 galvanized iron; No. 24 galvanized iron above 3′ 11″ high on sides; No. 20 galvanized iron in ice hatches.

These cars are equipped with collapsible ice tanks. It will be noted that the loading space with the bulkheads down (or so equipped that ice may be used in transit) is 33 ft. 5¾ in. With the bulkheads raised (when car is to be used under ventilation), the loading space is increased to 39 ft. 8¼ in. The great advantage of increased loading space of cars under ventilation can at once be seen as compared with the old style ice bunker, which was permanent.

These cars are equipped with Bohn patent venilators which are operated, opened or closed, by means of levers, one attached to each ventilator. This is a great advantage over the old style ventilator, which required a large amount of labor in order to adjust, on account of the necessity of pulling heavy ice plugs up from the bottom of the ice tanks when placing them in position, when it was necessary to close the ventilators, and reverse the operation when opening the ventilators. This feature will not only save a lot of unnecessary labor in handling ventilators on cars in transit, but will materially cut down delays on the road, caused by the necessity, in many cases, of placing trains on the side track in order to manipulate the ventilators when weather conditions necessitated.

The capacity of the ice tanks of these new cars is 10,000 pounds (each tank 5,000 pounds).

The cars in this series have steel underframes.

The data just presented form a very fair criterion indeed upon which to build for the future.

In conclusion, however, a few words must not be omitted about another aspect of refrigerator car service, which has a vital bearing upon refrigerator car construction. That is the question as to the measure of legal liability which attaches to the initial carrier issuing

the bill of lading. Under the ancient theory of the common law, the initial carrier had quite fully performed its own duty when it had hauled the freight in reasonably good condition to the end of its own rails, and therefore a car was satisfactory which would accomplish that limited purpose. There are some authorities who now contend that that ancient rule was exploded when the Federal Congress adopted the Carmack Amendment to Section 22 of the Interstate Commerce Act, which was reaffirmed not many months ago by the United States Supreme Court in its several decisions on the question of released valuations. Under the Carmack Amendment the initial carrier is made responsible for the first payment of damage claims, regardless of where that damage may occur, although it has recourse against its connections for equitable reimbursement or adjustment of the claim in due course. While the question of Federal regulation of bills of lading on interstate commerce has not yet been finally settled by the National Congress or by the Interstate Commerce Commission, it is, nevertheless, very clear from the recent decisions of the United States Supreme Court that in this matter the state regulations heretofore applied are nullified by the Federal Act. The apparent significance of all that is that, as Commissioner Lane has said, the American people are living as a nation, and the ultimate standards will become more nearly universal throughout the country than they have been up to the present time. The ever present possibility of the reconsignment of perishable freight in transit renders it increasingly imperative that so far as practicable a standard car of maximum efficiency be generally employed. The railroads, to whom all credit is due for the wonderful development of perishable freight traffic in the United States, will undoubtedly follow the same liberal and progressive policy which they have pursued for so many years and, therefore, may reasonably be expected to co-operate to the fullest extent in the search for better and more economical methods if obtainable, but in this search all must recognize certain unavoidable limitations.

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NOTE—**The papers by Mr. McPike and Mr. Bracken, both on the same subject, were discussed jointly and the complete discussion follows Mr. Bracken's paper.**

No. 119

THE REFRIGERATOR CAR—RETROSPECTIVE AND PROSPECTIVE

By J. H. Bracken, Chicago, Ill.

(Associate Member of the Society)

It is, I believe, a remarkable example of the "eternal fitness of things" that at the first meeting of this Society in December, 1905, there was a paper and a discussion about the transportation of perishable food stuffs under refrigeration. This is a fitting subject for refrigerating engineers, because the humble refrigerator car is the seed from which has sprung the enormous developments of the refrigerating industries in this country.

The refrigerator car has created the meat packing industry and has stimulated beyond all measure the fruit and vegetable growing industries. It has made it possible to transport fruit and vegetables across the continent and across the ocean; it has resulted in the development of large areas of our country which otherwise would have remained poor on account of their distances from market. It has made possible the building of the enormous cold storage buildings, whose problems this Society is organized to study. Every branch of the refrigerating industry, save possibly ice making alone, is largely dependent for its existence on the safe transportation of perishable food stuffs, and this means that all these things are dependent upon the refrigerator car. It is well to keep these facts in mind before condemning sweepingly and thoughtlessly the present development of refrigerator car service in this country.

EFFECT ON THE MEAT BUSINESS.

A word or two about the developments spoken of above may be interesting. I will quote freely from Mr. Weld's interesting monograph:

"Meat in early times was furnished by local slaughterhouses and the live animals were either shipped in the ordinary cattle cars of the railroads from the West to the Atlantic seaboard, or raised locally. There were extensive stockyards and slaughter houses in all the principal cities of the East, and the carriage of live animals was an important item in the traffic of the railroads. About 1870, dressed beef began to be shipped from Chicago to eastern markets in refrigerator cars, which will be described later.

"It is easy to realize what great economics were made possible by this change. The weight of edible beef derived from a steer

is only 50 to 57 per cent. of the entire weight of the animal. In those early days all the rest was absolute waste, and the slaughter-houses even paid sometimes to have it carted away. In other words, shipment of cattle meant the payment of freight on a steer weighing 1000 pounds in order to get about 550 pounds available for market. Furthermore, there was a deterioration in the value of cattle after a carriage of 1000 to 2000 miles in cattle cars; many became sick and died en route, there was always a considerable shrinkage in the weight of the animals, and the quality of their meat was impaired. These economies were readily recognized and the shipment of dressed meats became general. As a result of this the great packing centers of the Middle West began to spring up, and consequently the slaughtering of cattle in the East began to fall off.

"The following figures demonstrate this tendency: The slaughter of cattle fell off in Boston from $7,000,000 in 1880 to $1,400,000 in 1900. It increased in Chicago from $85,000,000 in 1880 to $256,000,000 in 1900. It increased in Kansas City from $500,000 in 1880 to $74,000,000 in 1900. The cattle raising country gradually extended farther and farther westward, and the Chicago packers followed this westward movement by erecting plants at Kansas City, Omaha, and even followed the industry to Texas and built great plants at Fort Worth. This shifting of the meat packing centers was made possible by the use of the refrigerator car.

"The westward movement of the cattle raising industry itself has likewise been made possible by the refrigerating car. In the early days, when live cattle were shipped, the distance from west of the Missouri River to the Atlantic coast was too great, and the expense of marketing the cattle too high to make the raising of livestock profitable. With the introduction of refrigerator cars the utilization of the vast growing districts of the West was made possible. Thus, not only is the entire dressed-meat industry dependent on the refrigerator car for its existence, but also the raising of livestock has been extended, and many States have been developed and made wealthier through its use. As the census of 1900 says: 'The importance of artificial refrigeration to the meat trade would be hard to overestimate. The most important step in the development of American beef as an article of commerce was the invention of the refrigerator car by William Davis of Detroit, in 1868.'"

EFFECT ON AGRICULTURE.

Fully as important as the part that the refrigerator car has played in the development of the meat packing industry, is its effect on agricultural development, in connection with both fruit and vegetables. It was not very long ago that fruit was raised only on a small scale, as it had to be consumed locally, and could not be transported for any considerable distance. Fruit could be had at any given place only at the time it ripened locally, and any that was brought by express or other means a little before or after the short season of three or four weeks was very expensive and considered a great luxury. As a result of refrigeration in transit these conditions have all been changed; fruit is carried from most remote sections of the country to the large cities throughout the year, and, instead of being considered a luxury, it is looked on as a staple article of food. As Mr. Armour says in his book on private cars: "The operation of private fruit refrigerator cars has changed the growing of fruits and berries from a gamble to a business, from a local incident to a national industry." Few people realize what an enormous business fruit growing has become under the impetus given it by refrigerator cars, and not even the Department of Agriculture has adequate statistics on the fruit crop, which Mr. Armour estimates at about $400,000,000 a year, in 1904. In 1889 the principal fruit growing districts of the country shipped under refrigeration only 9,164 cars; in 1905 the same districts shipped 42,982 cars. This gives some idea of the rapid growth during the past few years.

Many sections of the United States have been developed for fruit growing in a very remarkable degree; the lower Mississippi Valley from Missouri south, including Texas, Georgia, and the Eastern seaboard, especially the Carolinas; Colorado, Arizona, Oregon, Washington, Idaho and Utah; in fact, in every section of our country there are vast areas given over to the growing on a commercial scale of horticultural and vegetable products which are dependent for their existence upon proper transportation in refrigerator cars. A glance at California will be sufficient to realize the enormous development of the fruit growing industry.

CALIFORNIA FRUIT INDUSTRY.

The first carload of 300 boxes of oranges from California is said to have been shipped in 1876 in an ordinary box-car without any refrigeration. Fortunately, this pioneer shipment came through in good shape, and the railroads made a special effort to

secure further shipments of this kind. In the beginning, box-cars were used with wire screens under the eaves for ventilation, and the shipments were carried only in cold weather. About 1887, refrigerator cars were introduced in the trade and the fruit began moving in larger quantities until, at present, there are approximately from 35,000 to 40,000 carloads of citrous fruits alone moved from California, and about 20,000 carloads of deciduous fruits as well. Mr. G. Harold Powell made a list of fruits moving under refrigeration in 1907 which I have altered slightly.

DEVELOPMENT OF SHIPMENTS IN REFRIGERATOR CARS IN 1907.

Arkansas and Missouri, 2,238 cars; Georgia, 2,500 cars; Western Colorado, 1,500 cars; Northern California, 7,750 cars; Washington, Oregon and Idaho, 2,000 cars; North Carolina and South Carolina, 2,000 cars; Delaware and Maryland, 1,000 cars; California citrous fruits, 15,000 cars; Southern Colorado, 1,234 cars; Arizona, 185 cars; cantaloupes from California, 1,050 cars; vegetables, Southern Pacific System, 3,893 cars; Santa Fe System, 869 cars. Vegetables and fruits, Illinois Central Railroad, 1,200 cars; New Mexico, apples, 17 cars; Oklahoma, melons, 3 cars, green fruit, 115 cars; Arizona, green fruit, 2 cars; Texas, green fruit, 5 cars; Colorado, vegetables, 233 cars; Texas, vegetables, 73 cars; a total of 42,862 cars for 1907—fruits and vegetables only.

I have taken out of Dr. Powell's list only the cars moving under ice. It is estimated that the refrigerator cars carry under icing not quite one-half the total shipments of perishable foodstuffs; the remainder of the cars, or more than one-half, going forward under ventilation.

TYPES OF REFRIGERATOR CARS.

It would be a tedious story, which I will not attempt, to recount every change in the refrigerator car during its development. The first carload of meat which was sent from Chicago to New York was shipped over the Michigan Central Railroad in an ordinary box car. A bin was constructed in each end of this car like a large box, suspended three feet from the floor, and each bin was filled with about a ton of ice; the meat was laid in on the floor and, by attaching these cars to fast freight trains, they were landed in New York in about three days in good condition. But those interested saw the necessity of much better equipment.

The first real refrigerator car was that patented by Mr. D. W. Davis of Detroit, on June 16 and September 15, 1868. "This car had an air space for insulation entirely around the top, floor,

sides and ends. To assist this insulating effect, there was placed two layers of hair insulation against the inner air space wall, and this was covered with an interior wooden shell. The ice tanks were placed along the sides of the car, and extended from the top of the car to within three inches of the floor. They were 4½ inches wide at the top and tapered to two inches wide at the bottom. They communicated at the top with funnel openings, and at the bottom drip pipes carried away the water resulting from melted ice. Through the funnel openings on top were put in broken ice and salt."

The railroads were opposed very strongly to this traffic, and did what they could to discourage it, for the reason that large interests in the stock yards of the Eastern cities were naturally opposed to the development of the dressed beef traffic and the railroads believed it meant a decline in cattle shipment. Mr. Gustavus Swift, however, arranged to use the Davis car, and induced the Grand Trunk Railroad, which did not handle much live stock and which, consequently, was not opposed to the development of the fresh meat traffic, to handle his shipments over that railroad. It is curious that the railroads at the beginning could not be induced to build refrigerator cars, and the enormous private car lines of the packers and other interests were made necessary from this fact. The railroads thought that the business never would amount to much and they refused to invest their capital in special equipment of this type. They have changed their minds since the '70s, however.

After the Davis car, which was run successfully, there were many improvements introduced. In short, it may be said that there have been three types: One, in which ice was placed in a tank, or tanks, suspended from the roof of the car and the cool air precipitated on the contents below; the second, in which the ice was placed in one or both ends of the car and the air within kept in circulation by a fan or other mechanical device; the third type, which is now nearly universal, has ice tanks at each end of the car and the air circulation is a natural one, obtained because of the relative density of cold air and warm air, and the displacements which occur when one is properly acted on by the other.

I may say in passing, however, that over 400 patents have been taken out on improvements in the refrigerator car. The general tendency of some of these patents I will criticize later. Many of these patented cars have been in operation for a short time

only, or have been represented by a small number of cars. Some of these cars were grotesque; many were tried out, especially several with mechanical devices—none has survived. I think, therefore, that we need concern ourselves, for the present at least, only with the best type of the present most generally used refrigerator cars.

In order to examine this car and have a real car in mind, I am going to consider the kind which are used in the California fruit trade, since these are the refrigerator cars which have the heaviest duty to perform, and since they have had the most careful thought bestowed upon them by the railroads and are, I believe, the best cars which have been produced in this country. The cars used for transporting beef are slightly smaller than the provision and fruit car, and have a different arrangement of the ice tanks; but, in general, both may be considered as one type.

This car has an inside length, excluding the ice tanks, of about 33 feet, an inside width of about 8-ft. 2-in.; an inside height of about 7-ft. 6-in.; in each end of the car there is an ice tank which holds about 5,000 pounds of ice, or 10,000 pounds for the whole car. The best type of car has a steel under frame, which makes the floor very rigid. A car with this steel under frame costs about $1,400.

I am going to describe closely the wall construction of this type of refrigerator car which is of interest from an insulating standpoint: This wall is, from outside to inside about 6½ inches in thickness; on the floor of the car upright posts 5 x 2 inches are erected on three-foot centers; in between these posts are braces, also 5 x 2 inches, running from the bottom of one post to the top of the next post, to stiffen the wall. Sometimes one, sometimes two belt rails of 3 x 1½-inch lumber are run midway between the floor and the top of the posts, in between the posts, as a further stiffening. Directly on these posts is applied the outside layer of insulation, either Linofelt—flax fibre insulation—or hair felt, ½ inch in thickness, running from the top of the posts to the floor. Over this, light furring strips ⅜ inch are placed following the lines of the posts, and the outside wood sheathing of the car is applied directly over these furring strips, nailed through to the posts, belt rails and braces. On the inside of the posts, what is called a "blind lining" of ⅜ inch lumber is applied, then on this blind lining is put the inside layer of insulation, also one-half inch thick, with a ⅜ inch nailing strip over the insulation, and

the 13/16 inch wood lining forming the inside wall of the car is applied over these furring strips. From an insulating standpoint, we have, therefore, outside to inside, a 13/16 inch layer of lumber, a ⅜ inch air space, a ½ inch layer of insulation, a 2 inch air space, a ⅜ inch layer of lumber, a ½ inch layer of insulation, a ⅜ inch air space and a 13/16 inch layer of wood. The floor and ceiling insulation is arranged in a slightly different manner, but it may be considered the same in thickness and efficiency, and it is unnecessary to go into too much refinement. If I were writing three years ago, I should say that this is the typical first class refrigerator car; but since that time, there has been a marked tendency to increase the amount of insulation.

All the cars which have been built for the California trade within the last two years have had at least three layers of ½ inch insulation, and one large refrigerator line has adopted as standard four layers of ½ inch insulation. Fortunately, we know quite accurately the insulating efficiency of the two-layer car above described, which has been the standard best car of this country up to quite recently.

In 1908 there were a series of tests conducted by the Santa Fe Refrigerator Car Line and the Pacific Fruit Express, which is the refrigerator car line of the Southern Pacific Railroad, in which were involved a very accurate examination of five cars, two of which were standard cars at that time; that is, like the car I have just described, with two layers of ½ inch Linofelt insulation, one of which had four layers of ½ inch Linofelt insulation and two of which had six layers of ½ inch Linofelt insulation. I am going to give you the results of tests on the standard car with two layers of ½ inch insulation, and the best of the other cars with six layers of ½ inch insulation.

For the sake of clearness, I will call the two-layer car the standard car, and the six-layer car the improved car. On October 7, 1908, in the early afternoon, these two cars were loaded at Narod, Cal., with Valencia oranges, each car containing 396 boxes, weighing 72 pounds each, or 28,512 pounds. The cars were delivered to an experimental precooling plant of the Southern Pacific Railroad at Los Angeles in the early evening, and went east from Los Angeles at 6 A. M., on October 8. This experimental precooling plant was a precursor of the larger plants which the Southern Pacific and A., T. & S. F. railroads have erected in California at points contiguous to the large fruit producing cen-

ters. These railroads aim, if possible, to have the fruit loaded into their cars in the day time and to have these cars reach the precooling plants at night, where the oranges are reduced in temperature to about 50° F. This experimental plant at Los Angeles, which is a type of all the new plants, had a large canvas duct, which fitted into one of the side doors of the car. This duct is about three feet in diameter. On two of the ice hatches, one at each end of the car, on top, was a smaller canvas return duct, about a foot and a half in diameter, leading back to the precooler. A large fan drove air through a coil bunker into the duct in the door of the car and back through the returns at each end of the car, on top. The new precooling plants have very long ducts with many branches, so that a whole trainload of fruit cars can be precooled at one time. The precooling of the test cars was done in about five hours, and I was told each car consumed about four tons of refrigeration in that time, if I remember correctly. Since this was late in the Fall, the temperature of the fruit was approximately only 68° F., although in the Summer season the temperatures of the fruit run to 90° F. and higher. In each car there was a thermograph placed near the center, on top of the load; there was a thermometer hung near the ceiling over the car door; a thermometer resting on the floor of the car in the center of the load; there were seven other thermometers scattered throughout the car, inserted in the fruit; one in each doorway, one in each end of the car; the others in oranges in the center of the boxes, midway between the floor and the ice bunker. These thermometers were read approximately every three hours for the nine days that it took to make the journey from Los Angeles to Chicago. Representatives of the Southern Pacific Railroad and the Santa Fé Railroad took the readings, often at great personal risk. More frequent readings would have been impossible without upsetting the entire railroad service. As it was, the train containing these two carloads of oranges was practically under the personal supervision of the above mentioned representatives. The routing lay through the hottest part of the country, via the Southern Pacific Railroad from Los Angeles to Yuma, Ariz., along the Southern boundary of the United States, through El Paso and Del Rio, Tex., into New Orleans and north from New Orleans on the Illinois Central Railroad to Chicago.

The standard car melted, on the nine days' journey, 12,055 pounds of ice. The average temperature of the oranges in this

car, after precooling, was 50.72° F. This was reduced to 42.14° on arrival at Chicago, a reduction of 8.58° F. in the temperature of 28,512 pounds of oranges. The oranges, therefore, consumed 1,592 pounds of ice, leaving 10,463 pounds as meltage through heat leakage. Dividing this by nine, the number of days, we have 1,193 pounds per day meltage, or, 169,406 B.t.u. per day. The mean exposed area of each car was 1,466 square feet. By this, I mean the area of the car midway between the outside and inside surfaces. Dividing 169,406 B.t.u. by 1,466, we have 115.55 B.t.u per square foot per day. The average outside temperature during the journey was 68°; the average inside temperature was 45.37, an average difference of 22.63. Dividing the 115.55 by the average difference in temperature, we have a heat transmission of 5.1 B.t.u. per square foot per 24 hours per degree difference between outside and inside temperatures.

The improved car melted 8,410 pounds of ice and reduced the fruit from 51.3 to 43.6, or 7.7° F. In doing this, the oranges consumed 1,422 pounds of ice, leaving 6,988 pounds to be taken up by heat leakage, or 780 pounds per day; or 110,760 B.t.u. per day. Dividing this by the mean area, 1,466, we have 75.55 B.t.u. per day. The average outside temperature was 68°; the average inside temperature of the improved car was 42.52° F., a difference of 25.48° F. Dividing this into the 75.55, we have a heat transmission of approximately 3 B.t.u. per square foot per 24 hours per degree difference. I should judge that the best transmission of the best type of refrigerator car now in use is midway between these two transmissions, and I should place it at from 4 to 4.5 B.t.u. per day per degree difference in temperature.

If the total exposure of all surfaces, air velocity and other things are considered, this is not a bad showing. One striking improvement shown by the heavily insulated car as against the standard car in the above test was the fact that in the standard car the thermometer on the top of the load in the middle of the car showed an average difference in temperature 10° higher than the thermometer on the floor; but in the improved car, the thermometer on top of the load showed only 4° higher than the thermometer on the floor.

The weak part of the refrigerator car which uses the gravity air system of circulation is that the fruit in the center of the car on top of the load will remain much warmer than the fruit in the other parts of the car, and the decay of the fruit begins at that

point. The thermograph readings of the two cars were very interesting, compared with the chart of the outside temperature; this showed that in the lightly insulated car the interior temperatures followed every rise and fall of the outside temperature, whereas in the heavily insulated car this tendency was so slight as to be negligible. The lines of the outside temperatures and the interior temperatures were plotted on a chart and the outside temperature is represented by a succession of waves; the trough of the wave was at midnight and the crest of the wave around noon the following day. In the standard car, there is also a trough and crest in the temperatures; but in the improved car there was scarcely a ripple to show the high and low points.

Now, the refrigerator car may be considered to have two functions; first, to refrigerate the load—to remove heat from the fruit; second, to carry the fruit without permitting the outside temperatures to affect it—to prevent the fruit from raising or lowering in temperature because of Summer or Winter outside. The best cars fulfill the second function very well. The two cars I have described, even the poorer one, could have carried the lading a month, with proper icing, without damage to the fruit. It is with regard to the first function, the refrigerating of the load, that the cars fail. It is to this point that Mr. G. Harold Powell addresses himself in the first volume of Transactions of this Society. He states the Georgia peach loaded at 75° to 95° F. is in the car two to five days before the temperatures reach 40° to 50° F. Oranges from California loaded at 60° to 90° F. are in the cars five days before they reach 40° to 50° F. And he explains that this slow refrigeration is the cause of decay, which is alarmingly large in the Summer season in cars refrigerated by ice. The cooling of fruit to 50° F. at least ought to be accomplished within 24 hours of the loading of the car. It is not possible to get 10,000 pounds of refrigeration which is needed for this work within 24 hours out of ice alone when the gravity air circulation system is employed as it is in all these cars. This is so because the air circulation stimulated by gravity alone is not vigorous enough to cause the rapid replacement of the air warmed by the fruit with a reasonable volume of cold air. The movement is sluggish and the consequent refrigeration is slow. And the so-called syphon systems are very little, if any, better than the plain systems in this regard.

I have only two tentative, very tentative suggestions for im-

provement: First, the use of ice and salt. The ice bunkers could be filled with ice and salt two or three times in the first 24 hours. and at the end of that time, by a proper arrangement, the bottom of the ice tank could be swung on hinges and dumped, or the sides of the tank could be opened and the ice and salt pulled out so that fresh ice alone could be put in for the rest of the journey. It would not do for the ice and salt to make the whole trip, for too low temperatures are as bad as too high ones.

Second, some simple automatic fan arrangement to stimulate the air circulation, could be installed. Several of these air circulators have been tried but abandoned, and the successful one will have to be as simple as Simplicity in her own proper person, requiring no expert attention, and putting no strain of any kind on the car or on the engine. It must have besides other qualities too numerous to mention. The movement of air around a car when it is in motion is an excellent motive force. Would it be practical to run a shaft from the floor of the car in front of the ice bunker through the roof with a fan on the roof for a motor and a fan in front of the bunker as an air circulator? Of course, the precooling plant solves the question very well in a place like California with its enormous tonnage, and, while there has been some criticism of it, I think it has reached a real solution and that many more such plants will be built. But in a smaller community with a few hundred cars moving during one month in a year, it is hard to see how the capital invested can make returns unless the precooling charges are made prohibitively high. A solution of this problem has been attempted by a man with a movable precooling plant, which was tried out in Georgia. He had an ice machine and a coil bunker with fan fitted out in a specially constructed freight car; he got his motive power at the town where he shipped his car, either steam or electricity, and he precooled one or two cars at a time. Perhaps this could be worked out for small communities with few carload shipments.

A third suggestion for rapidly refrigerating the loads must have occurred to all of you, and that is mechanical refrigeration. This is the last question Mr. Powell asked you seven years ago—Does any method of maintaining a low temperature in a refrigerator car seem more practical than the use of ice? The NO which answers this question can be shouted more certainly now than it could seven years ago. The railroads which move refrigerator traffic have invested literally millions of dollars in ice plants and

ice gathering equipment, and have induced private investors by long-time contracts to invest other millions for the same purpose. Every trunk railroad has a series of these icing stations on its line to care for refrigerator business, both local and through shipments. These millions of dollars stand like a mighty bulwark against changes in the present universal system of icing refrigerator cars. Any mechanical refrigeration device to overturn this bulwark must have merits so overwhelming that they can be seen at a glance by all men, even railroad presidents, who will be found, I am sure, very near-sighted.

Unfortunately, the railroad experience in the past with novel refrigerator cars has not been happy. There is an overwhelming prejudice against devices which require attention on the road. The railroads will not have them. Two systems have been proposed: The first, a refrigerating plant in a special car to do service for a whole train like the lighting systems. These are objected to, because a car may have to leave the train at any point because it is in bad order, or for delivery. What happens to its refrigeration? Then again, you cannot put a big enough plant in any kind of a car to refrigerate 30 to 50 cars in a modern trainload. There are many other objections, but from a railroad standpoint these are conclusive. This brings us to a mechanical device for each single car. Nothing yet developed has ever received serious consideration by the railroads. Let me give a recent example: A member of this society proposes the ethel chloride machine with a special compressor; a novel condenser worked with a pump using condenser water carried in a tank under the car and three coils of 1-inch direct expansion piping on the ceiling of the car. The motive force is supplied by a belt driven by the axle of the car when it is in motion. The author says that 5 H. P. is all that is needed to drive his compressor, or pump, and the engine will not feel this. Supposing a very usual train of 30 cars you would have 150 H. P. and to start the apparatus, double this, or 300 H. P., which I am afraid the engine would feel and loudly object to. The author says in effect further that only six attendants are needed to accompany a 30-car train, which the railroads would object to seriously. What is to be done when the car is not running; if it has to be cut out of the train because of a bad wheel and you are facing the payment of $1,500 for a spoiled load? I am taking the railroad viewpoint in this, for I have no doubt that this machine is a praiseworthy device.

I cannot refrain from a last example to show the antagonism of the railroad viewpoint toward devices on refrigerator cars which require attention from the train men. A gentleman in Sweden has patented a refrigerator car in which brine made from ice and salt is pumped through coils to cool the load. The pump is operated from the axle by a belt and when the car stops the pump stops. Careful instructions to the railroad officials to work the pump by hand when the car was stopped were issued with this result, quoting from selected sentences: "Under no conditions is it allowable to eliminate the pumping as they do at the railway station of Malmo. When it is, of course, no Fregator Van is scarcely an ordinary cooling van. People do not take into consideration what enormous values get lost to our country, our agriculture and our economy as a consequence of this routine and this intolerable state of things." All that is because the brakeman wouldn't work the pump.

What of the future insulation of this equipment? I think this can be improved without thickening the car wall or adding materially to the weight, which is a bugbear, for the cars weigh now 40,000 to 50,000 pounds and are far too heavy.

The quilt insulations ought to be retained, because of their lightness and efficiency. They can be applied on each side of the posts in the walls, but the 2-inch air space bounded by the posts and braces should be filled with a light insulation. This will give the wall 3 inches of insulating material, as against 1½ to 2 inches, which is the greatest thickness now. In the roof two extra layers of ½ inch felt, making five in all, should be applied, because the roof has the greatest exposure and needs more insulation than the walls. The floor needs special treatment because water from the ice-tank frequently floods it and wets and rots the floor insulation.

The Pennsylvania Railroad on its latest cars is using Nonpareil cork board in two 1-inch layers, laid below the floor boards to avoid this rotting if possible. Any floor insulation, in my opinion, should be especially protected by an impervious waterproofing course above it. Where water has access to the insulation, it will carry deleterious organisms from the foodstuffs, especially meats; these will lodge in the insulation and cause a nauseous mess, for which no type of insulation can be blamed. The floor of the car itself must be waterproof.

DISCUSSION

C. C. Palmer.—I have read with great interest the papers of J. H. Bracken and E. F. McPike, on "The Refrigerator Car—

Retrospective and Prospective," and I recommend to every member of this Society that they read these papers carefully, as they contain valuable information upon the refrigerator car service. The Railway & Stationary Refrigerating Co., which I represent, was the owner of the mechanically cooled refrigerator car mentioned in Mr. Bracken's paper, and for the purpose of correcting any impression that may exist as to the improbability of a refrigerator car cooled mechanically, I wish to answer these papers in so far as they refer to this type of car.

I am interested in the prospective side of the question. Take that branch of the art of refrigeraton as applied to railroad cars and look backward—what do you note? You will find the methods of handling the highest class and most profitable branch of the railway service has undergone little or no improvement in the last thirty years. I will acknowledge that the trucks of the cars are more substantially built, that steel underframes have been adopted and the insulation of the walls of the car greatly improved, but the vital conditions that are actually necessary to the successful carrying of the perishable freight have not been attained. I will venture the assertion, that if a test was made to-day by using the methods of the old Davis car, the Tiffany car or the Wicks car, installed in a modern built car of to-day, with the proper proportion of radiation surface, in competition with any or every one of the modern cars now in use, all to be loaded with the class of freight for which it was designed and hauled upon the same train, that there would be no perceptible difference in the condition of the freight when delivered.

What a marked contrast there is between the improvements of every other department of the railroad service and the refrigerator car service. Our Society has had several papers read at our meetings at different times touching upon this subject, and in each case the author has acknowledged that the present method is seriously defective, and suggesting that a mechanical refrigerator car is desired, believing it will remedy these defects. None of these papers say that the railroad officials wish such a car and Mr. Bracken's statement that "Nothing yet developed has ever received serious consideration by railroads" is perhaps true. He follows this with a reference to our refrigerating apparatus using ethyl chloride, which I shall not answer in detail, but will further on make a positive statement of what we will offer to do.

The authors of these several papers, having decided that a mechanical refrigerator car should solve the problem, proceed to tell us what we are prohibited from doing in this connection. Mr. Bracken says: "There is an overwhelming prejudice against devices which require attention on the road. The roads will not have them." He also gives an example to show the "antagonism of the railroad viewpoint toward devices on refrigerator cars which require the attention of the trainmen."

Mr. McPike says in his paper, in referring to men in charge of cars to care for the machinery: "This would be an insurmountable objection, as it would not be at all practicable for railroads to adopt any such policy."

As I think over the several instances where men are sent to care for the several branches of the freight and passenger service, I find the following: The Pullman Co. has its conductors to handle the money and the porters to manipulate the intricate mechanism of the sleeping berths; the express companies have messengers in charge of cars; the United States mail service has its men; the live poultry cars are in charge of men, usually the owner of the stock; the shippers of live stock of all kinds, aggregating hundreds of cars each day, send men to care for their property; the shippers of bananas occasionally send men to care for their property, and shippers of potatoes often send men in winter to keep the heaters in order to prevent freezing. However, the moment a mention is made of an attendant to care for a mechanical refrigerator car, apparently the whole operating force of the refrigerator car lines offer, what they term, serious objections—the attendant in charge of the car. Perhaps this question is not considered by the actual railroad officials as serious as our friends would have us believe. If this is the fact, who are those who are objecting so strenuously? Mr. Bracken says: "The railroads which move refrigerator traffic have invested literally millions of dollars in ice plants and ice harvesting and storing equipment, and have induced private investors by long time contracts to invest other millions for the same purpose." Perhaps these "private investors" with their fat long time contracts are the real objectors. Mr. Bracken omitted to say that these same "private investors" own and operate several thousands of refrigerator cars and, until broken up by the Interstate Commerce Commission, had practically a monopoly of the fruit carrying trade of this country.

Our company has spent many thousands of dollars in perfect-

ing a mechanical refrigerator car, and in operating these cars we have been continually annoyed by having them diverted from their route, twice with our men in charge of the car. In fact, we have had it stolen, that is, sent out of the railroad yards without a record of any kind being made either in the yard master's office or on train sheets to indicate where it was sent. We stood these annoyances three or four seasons, until tired of fighting the battle alone and, except in the matter of passes for our men, at our own expense.. Several years ago we decided to abandon all further efforts in this line, and await the time when the railroads will request us to furnish a refrigerator car that will correct the defects of the present iced cars, and pay their share of the expenses of a demonstration, and besides protect us against the diverting of our car and interference of every kind in our work. I believe that sooner or later this proposal will be made to us, for the demand for a perfect car is constantly growing stronger and we know our car will fill the bill.

Mr. Bracken says, referring to the present ice car, "It is with the first function, the refrigeration of the load, that the car fails." He also states in his paper that it requires from two to five days for the center of the load to be cooled to a temperature of 40° to 50° F., and gives as a reason the slow movement of the air by natural circulation. When we were demonstrating our car, ten or twelve years ago, we called attention to this fact and were laughed at. Our cars are provided with means for rapid cooling and forced circulation, two of the several points of superiority of our car over the iced car. He further says: "The author says that 5 H.P. is all that is needed to drive his compressor or pump, and the engine will not feel this." He then cites a 30 car train at 150 H.P. and proceeds to double this, making 300 H.P. No one connected with our company has ever claimed the engine would not feel the load. The question of horse power we are ready to take up at any time with the master mechanics of the railroads who we know are competent to treat upon this subject. The clinching blow of all, however, is delivered when he asks: "What is to be done when the car is not running?" He evidently never looked at one of our cars or even a picture of our machinery, for if he had he would have noted the fact that we had a kerosene oil engine to use when loading or when subject to any long delays while in transit.

The precooling of fruit before shipment has been a decided advantage, and has been so acknowledged by every one, also that a

more rapid circulation of air in the car during transit is absolutely necessary. These are two of the several important claims of superiority in our car.

Mr. McPike says: "The principal desiderata are efficiency and economy, both to the railroads and the shipping public." If he voices the opinions of the railroads there is yet some hope for us.

One more reference to Mr. Bracken's paper where he says: "Mr. Powell asked you seven years ago, 'Does any method of maintaining a low temperature in a refrigerator car seem more practical than the use of ice?" I was present at the meeting when that question was asked, and was led by this question to believe that we would be able to demonstrate that there was a better method. I wrote to the United States Department of Agriculture, sending copies of our catalogue and a description of the car, and offered to place one of our cars in any service they might select, send a man to care for the car and pay all expenses of the demonstration in so far as our car was concerned. We received in reply the statement that it was against the rules of the Department to exploit any private enterprises.

Again on September 9, 1907, we wrote to the Department of Agriculture, saying that we had noticed in a news item in the trade press that the Department was to build a special car under the directions of S. J. Dennis for the study of the question of fruit transportation, and offered the use of our car, or should they not wish to use ours, we asked for a chance to construct the machine, believing that our experience in this line might be of advantage to them. This secured no better results than our former letter.

Now I will tell you our opinion of what a refrigerator car should be and, it is one that insures the "desiderata of efficiency and economy." To do this it must be equipped with means of varying the refrigerating effect, as the climatic conditions require; it must be provided with forced circulation of the air, that the load may be cooled rapidly; it must be able to absorb to a large degree the carbonic acid gases generated by the ripening fruit, it must maintain an even temperature throughout the car, thereby protecting the top row of fruit, as well as the bottom row. It must produce a dry air, not only for the advantage of the load carried, but to make it available for return freight; it must be able to produce any given temperature required, in order to carry any and every class of freight. The beef car of to-day is worthless in the fruit

trade and vice versa. It should also carry means of protecting its load against freezing, even in an extended blizzard. It should be provided with means of keeping the machine in operation when loading, or in case of excessive delay. Such a car requires an attendant, not necessarily an expert, but such a man as could operate an automobile. There are some advantages in having a man in charge, as he can foresee a heated term and provide for it by speeding up his machine if necessary. He can report progress on the road and notify consignee of probable arrival at destination; he will prevent side-tracking for any trivial cause, and watch the journal bearings under the car, thereby preventing heated journals while in transit.

This indicates what we propose to furnish the railroads when they wish to take the matter up seriously, with the intention of adopting it when we prove its value. Full working plans have been studied out for the purpose of operating these cars to advantage.

We do not advise the use of our car in the local "pick-up" trade, our object being to handle the long haul work originating upon the irrigated lands of the great West, South and Southwest, where ice does not form. We will do the precooling while loading and on the road, thereby saving 24 to 48 hours of time now consumed in precooling and icing in transit, and we will do this at a less cost than that of the iced car, provided two or more cars are on the same train.

George A. Nichol.—These papers bring out clearly very important details in refrigerator car design. It will be noticed that from the time of the first car spoken of, constructed in 1868, there seemed to be three very important points to consider, first, correct refrigerant, secondly, proper insulation, and last, a point brought out in these two papers that is being given great consideration by almost all railroad engineers to-day; that is, the proper waterproofing of the floors.

The insulation question is a very important one. Experiments have been made with all types of insulation, especially since the first car in 1868, which used the old type of standard hair felt. On about 90 per cent. of the cars to-day, this form of insulation is still being used, modified more or less by being made up in a quilt or felted form with a waterproof paper stitched on both sides. A test has been made of three to five courses of this insulation, but it may be interesting to know that, on a num-

ber of these tests, which seem to have been borne out in the paper, three courses appears to be about the commercial limit and as much as can be expected in consideration of the efficiency obtained. The Pennsylvania Railroad cars are referred to, and in order to correct an impression that might be taken from these papers in regard to cork being used for insulation entirely, I might say that it is used in the floors, the principal reason for that being a desire to get away from the filthy condition underneath so many refrigerator car floors. If anyone has ever made an inspection of a refrigerator car, the odor will be remembered, particularly after the car has hauled any number of different commodities and especially if it has been used in beef transportation.

The Pennsylvania Railroad decided to use cork in the floors and white-leaded all of the joints of the flooring in order to get it as nearly waterproof as possible. I have seen some cars where the floors were caulked the same as on shipboard, in order to give the correct waterproofing. On the Pennsylvania Railroad cars, the cork was applied to the bottom in three courses, and extended up twelve inches in height on the sides, so as to prevent capillary attraction carrying water up into the hair felt. The insulation in the side walls, roof and ends was three courses of hair felt. Those cars possess almost the ideal insulation efficiency, and makes it possible to keep down the thickness of the side wall to four inches from the outside sheathing to the inside lining. The insulation in those cars is applied in what can be considered the most correct manner, for the reason that other designs of refrigerator cars used side and diagonal posts for bracing, and of course the insulation had to be cut up to fit in between them. Consequently, it will be noticed by going into those cars, that a frost line appears, showing the outline of all the vertical and all the diagonal posts. On the Pennsylvania Railroad cars the insulation is carried in three complete courses, unbroken, from side door to side door. On a number of tests made, they have found it possible to maintain an average temperature of approximately 40 degrees F. They are using this same type of car with steel exterior for milk service, carrying milk into Philadelphia at temperatures stipulated by the city authorities.

Refrigerator car insulation should be impervious to moisture. Car roofs up to the present time have been made of two courses of roof boards with a plastic material between, and in the last ten years, outside metal roofs have been used. These roofs have

been more or less leaky; consequently, the entire insulation has been wet and of course that has reduced its efficiency. A number of the railroad engineers are now considering insulation that will not absorb more than its own relative weight in water.

In 85 cars of the Wells-Fargo Express Company there has lately been applied what is known as the membrane system of waterproofing of floors, similar to what is used on railroad bridge structures, that is, applying asbestos felt to the floor, then two courses of saturated burlap, with asbestos felt on top, bringing that up six inches on the side and laying a scratch course of asphalt mastic, imbedding into that a re-inforcing material, and over that an inch course of asphalt mastic. This is applied hot, being carried from kettles on the outside into the car, then worked with floats and brought up six inches on the sides. This makes an absolutely impervious floor. It will not take up odors. It is similar to what is being used now in a great many machine shops, breweries and dairies. It is possible by placing an expansion joint on each side of the door and filling this with a rubbery asphalt, to take care of the expansion and contraction. These cars have been in use over a year and on careful inspection there is absolutely no sign of cracking. It is possible to use a hose for flushing out the car.

In regard to mechanical refrigeration of cars, that is a subject we have been working on for some time, and while a number of years ago in the railroad end, we considered that mechanical refrigeration was something in the future, still I agree with Mr. Palmer it is something that is going to come and come possibly before we know it. It will not come in the long refrigerator car trains, but it will come in trains of milk or express cars where preferred shipments are carried, or where there are eight or nine cars in a train. We have been experimenting and have prepared plans, although we are not ready to do anything on it, with the Audiffren-Singrun refrigerating machine, which is a small unit, working on the assumption of one machine for each car. For instance, to apply this to an express car, it could be done by taking power from storage batteries under the car, or connection with a motor generator; there is only one difficulty, and that is, the cost of any installation for mechanical refrigeration becomes almost as great as the cost of a refrigerator car itself, and when that is brought to the attention of the operating officials of the railroad, it is a very vital one, because it runs into a large expenditure. Therefore, when you have an outlay of $1,400 for a refrigerating outfit and the

car itself only costs that much, you can see it is a rather difficult problem.

Charles H. Herter.—Most of the refrigerator cars I know about have the ice tanks in the ends. We have had representatives here from the United States Department of Agriculture who pointed out that with that system it was naturally difficult to get the proper low temperature throughout the car. A certain low temperature obtains in the bottom of the car, and a temperature five or ten degrees higher than that near the ceiling, to the detriment of the upper tiers of packages. I want to know if any car has been tried with the ice bunker placed longitudinally through the center of the car? It would seem to me that with this arrangement the cold radiated from the ice bunkers would first of all benefit the goods in the car and lastly come to the walls. By having the ice bunkers at the end of the car, you increase the heat transmission there, because you have a greater temperature drop between the outside and the ice, while with a longitudinal ice bunker a better cooling effect would be obtained, and, in addition, by having the entire cooling surface extending from end to end of the car, except in the door way, you would have more cooling surface and a better distribution of the cold than at present. If it were feasible to arrange this central bunker so that it would be collapsible, it would also be possible to slide it up against the roof of the car, out of the way. As to filling it with ice, you could have four openings, just the same as now. The gravity circulation of the air would force the cold air down and would cool off the goods and rise, naturally, as it should, then it comes in contact with the outer wall of the car, and returns to the bunker to be cooled off again. In this way the air would have a very short passage to travel, so that we ought to get a nice distribution and a uniform temperature throughout.

President Neff.—I think that has been tried.

Charles H. Herter.—Presumably the details were never worked out properly.

John E. Starr.—I may say it has been tried and the main objection to it was the difficulty in connection with loading and unloading the car, which was almost insuperable.

Charles H. Herter.—One of the latest ideas advanced is to have the cooling devices along the ceiling. To that there are several objections, one of them being the danger of upsetting the car in going around a curve.

John E. Starr.—The railroads won't have the weight of the ice, etc., in the top of the car.

*J. H. Bracken**.—Referring to Mr. Palmer's discussion of my paper, I beg to say that, I did not intend to deny the possibility of operating refrigerator cars with mechanical refrigerating devices, but only endeavored to set forth clearly the present railroad viewpoint of this matter.

There can be no doubt, in my mind, at least, that the railroads at present are not disposed to consider seriously a device like Mr. Palmer's, and I only picked out his machine because I thought it probably the best adapted for its purpose of any that I heard of. The problem before the refrigerating engineers is to get the railroads to try out even the best devices, and the energy required to remove the inertia of the railroads will be smething tremendous. It is scarcely necessary for me to say, however, that every advance in any line of endeavor is attended with great difficulty, and in pointing out the attitude of the railroads, I but intended to make clear in that far, at least, the way which must be traversed by the refrigerating engineer.

With reference to the discussion of Mr. Nicol, I beg to say that there are one or two statements which he makes that are inexact by about sixty per cent. For instance, he states that ninety per cent. of the cars to-day are insulated with hair felt; but when it is remembered that none of the Trans-Continental fruit lines are using hair for insulation, with a possible exception of a few cars, it can be imagined that the percentage claimed is due more to the enthusiasm of the salesman than to a patient investigation of the facts. I am sure that less than 50 per cent. of the refrigerator cars built in the last three or four years have used hair for insulating purposes. One reason for this is given unconscientiously by the gentleman himself when he refers to the odors which may be perceived in some refrigerator cars. These odors may be due to the decomposition of animal matter in the hair, as indicated in a paper read at the twenty-first annual meeting of the American Warehousemen's Association, and to be found in the proceedings published December, 1911. There are other inaccuracies in this gentleman's statement which show that he has not first-hand knowledge of the refrigerator car.

**Author's closure under the rules.*

No 120

CHEMISTRY OF RAW WATER CAN ICE

By John C. Sparks, New York, N. Y.

(Associate Member of the Society)

In continuing my studies on raw water can ice, and especially the difficulties that have been met with in practical operation, I have collected some new data in addition to the facts I have already published on this subject.

Within the last two years I have had occasion to go to a relatively large number, considering the total number of plants installed, of raw water can ice plants where trouble had arisen affecting the quality of the ice produced. By quality in this sense I mean the clearness of the ice and its freedom from matter in suspension, commercially the distinction between merchantable and unmerchantable ice.

Some time ago I had to go to a plant in upper New York State and found at this plant, that very poor ice was being produced, although the raw water was not exceptionally high in mineral matter in solution. The ice, however, was being frozen in 1,200 pound cans and whereas the total solids in the raw water were only 8.35 grains per gallon, in the core of the ice the content was 24.31 grains per gallon, the deposit being a white granular, coarse precipitate with a distinctly bitter taste, which was composed of more than 85 per cent. calcium carbonate, 10 per cent. of magnesium carbonate and the remaining 5 per cent. being silica, oxide of iron and organic matter. The precipitate represented approximately 700 grains of solid granular matter in each can, showing that carbon dioxide, which holds the carbonates in solution, is removed from the water by means of air agitation in exactly the same way that this air agitation removes the air dissolved from the water. Consequently the carbonates are precipitated and the trouble of a heavy opaque core ensues.

At this plant the temperature of the brine tank was about 10° F. with no additional air agitation provided for the drop in the brine temperature from the normal of 12-14° to 10° F. In another plant, in which conditions were entirely different and which I will take up later on, the brine temperature on account of the salts in the water to be frozen, had been dropped down to be-

tween zero and 2° above Fahrenheit, the air agitation, however, remaining constant. It is very evident that the designers and operators of raw water can ice plants do not have a clear idea as to the amount of air required and do not appreciate that the quantity of air required for agitation is dependent on the speed of freezing.

In no plant that I examined was there a proper system of recording, side by side or within easy reach, the brine temperature and the pressure of air used for agitation. In most plants a blower is used and the air passing from the blower is either refrigerated by some means to drop its moisture or partially dried. During this process the pressure is materially reduced and in a great many cases reduced to a point that does not supply proper agitation when compared with the rate of freezing.

It must also be understood that different waters require a different degree of agitation. The greater amount of mineral matter dissolved in a water, the more agitation is required. For instance, I found in my experiments on this subject, using waters made up to contain known contents of mineral salts that as I increased the amount of mineral matter in solution I had to increase the amount of agitation. As an example, with 50 grains of calcium carbonate per gallon, clear ice could be made with the usual agitation, that is to say clear ice could be made on the outside of the can. The core of ice made from water as heavy in mineral content as this, would be very poor. With 75 grains of calcium carbonate, the first ice formed on the side of the can was not clear until considerably more agitation was used. In exactly the same way, with calcium sulphate clear ice was formed with 20 grains in solution, but with 30 grains the agitation had to be materially increased. With the magnesium salts the limits are very much lower. Ten grains of magnesium carbonate present in the water, make the ice very cloudy and distinct spots were formed in the ice. This spotty ice, frequently met with in raw water can ice, showing patches of cloudy ice throughout the clear ice, is a very general indication of an excess of magnesium salts.

Quite recently I have had occasion to examine a raw water can ice plant near New York City, where the ice was particularly poor. The air was introduced at the side of the can and about 2½ inches of clear ice was formed all around the can and from that point on a heavy white core was made. A large amount of white precipi-

tate was shown to be distributed throughout the core and on examination this proved to be about 72 per cent. calcium carbonate and the remainder magnesium carbonate. The raw water in this case contained more than 22 grains of solid matter per gallon, and without purification should not have been used for the purpose of making raw water can ice. A sample of the water taken from a can which was three-fourths frozen showed about 54 grains of solid matter per gallon, but showed a very interesting distribution of the solid matter. For instance, I have just stated that the deposit thrown down by this water was chiefly carbonate of magnesium and calcium. In the core the carbonates had only increased about 2 grains per gallon, whereas the sulphates had increased about 8 grains per gallon. The sodium chloride, on the other hand, had increased from 3½ to 25½ grains per gallon. This entirely bears out the previous data obtained, namely, that of the calcium carbonates about 97 per cent. are eliminated during freezing, whereas magnesium carbonates are eliminated about 20 per cent. and magnesium sulphate about the same figure.

It therefore has to be remembered in considering the value of a water for raw water can ice: Firstly, will there be enough carbonate thrown out of solution to form a heavy core in the center; and secondly, will the magnesium salts, which are not eliminated to such a large degree and which, except for the carbonates, are soluble, be precipitated to such an extent that they will form a cloud due to matter in solution and not to matter in suspension.

Another important point, as disclosed by these analyses, was the question of the lowering of the freezing point of the ice left when the cake was nine-tenths frozen. This water contains more than 100 grains of sodium chloride per gallon and about 50 grains of other soluble material, and had its freezing point lowered to about 26° F., consequently taking into consideration the insulating effect of the ice already formed on the can and the reduction in the difference of thermal head between the brine and the water to be frozen, and also the decrease in the specific heat of the solution as compared with the water, and also the latent heat of crystallization of the salts in solution, it will be easily seen that not only was the freezing retarded but actually more refrigerating work was required to produce one pound of ice in the core of the can ice from water of this quality than would be required from a water whose composition is satisfactory for the manufacture of this product.

There is one great consoling thought, however, in this problem of raw water can ice. It is the carbonates that cause most of the trouble and the carbonates are more easy to get rid of and eliminate from a water than the sulphates. It must be remembered that it is a very dangerous thing to entrust the purification of a water for raw water can ice to anyone not entirely familiar with the subject. For instance, in the plant I first referred to, they endeavored to get rid of the matter in solution by using tri-sodium phosphate, soda ash, caustic soda and other similar compounds. They entirely overlooked the fact that the sulphates do not need removing and could not be removed without the formation of sodium sulphate as a substitution product. It is a well known fact that when a solution of sodium sulphate is cooled and its temperature reduced to near the critical temperature of the solution, which critical temperature is dependent on its density, pure crystals of sodium sulphate begin to be separated from the water at a higher temperature than the critical crystal temperature of the water, that is to say the sodium sulphate produces crystals on the outside of the can if present in large quantities. If present, however, in small quantities so that the solution is dilute and its temperature of crystallization is near the temperature of the crystallization of water, it being a fact that this critical temperature is dependent on the density of the solution, the first ice that is frozen on the outside of the can is cloudy and at times opaque. Practically what results from this method of purification is that the cloudiness that before was in the core of the raw water can ice is now transferred to the outside of the cake and as you can readily imagine, makes a very much worse appearance than it did as a heavy core.

As previously indicated, the main question of purification is the carbonates and these must be removed without the production of a secondary product. Any rational system by which the carbon dioxide gas may be separated from the water before the water enters the ice cans resulting in the precipitation and, therefore, easy removal by precipitation and sedimentation of the carbonates, should be made in some convenient manner before the water is allowed to enter the fore cooler or considered fit for ice making.

It may be that I have seen more bad ice made by the raw water can ice system than most people have for the reason that if a raw water can plant produces satisfactory ice, I am liable merely to

hear of it and not see it; on the other hand, if it produces bad ice I am reasonably sure not only to hear of it, but also to be called in to remedy the trouble. On that account possibly I may have a more serious idea of the difficulties in making raw water can ice than most of you have, but certainly there are a number of things strongly impressed on my mind.

I have recently conducted a series of tests on the subject of the proper amount of agitation with the purpose of correlating the three factors, namely, size of can, temperature of brine and quantity of mineral salts in solution, to determine a method for adjusting the quantity of air required to meet the conditions.

As a first consideration the air supplied for agitation must be considered at the point of inlet to the cans or as near this point as is practicable. A pressure gauge near the blower, while of value to determine the work done by the blower, is of little value in the final consideration as the pressue is materially affected by the cooling done to deposit the moisture contained in the air, the initial temperature of the air, the distance of the blower from the outlets in the cans, etc.

In making a start to establish a basis on which figures could be obtained, I found by experiments that the least quantity of air that is required by a good water low in mineral salts, such as Croton water, in a three hundred pound can, freezing at a brine temperature of 14° F. was 0.65 cubic feet of air per minute. This is rather more air than is actually supplied in some plants for the work, but on reducing the air, ice of inferior quality was made.

Rotary blowers will furnish between three and five pounds pressure at the blower. The travel through the pipe and the cooling reduces the effective pressure. Taking summer conditions with air at 80° F., if cooled to 40° F., the original pressure of 5 pounds, with constant volume becomes 4.6 pounds and 4 pounds at the blower becomes 3.7 pounds. The actual loss is greater than this.

Taking a standard 300 pound can to be 11x22x44 inches filled to about three inches below the top of the can and considering an air tube inserted to a point twelve inches from the bottom, the pressure of water operating against the free outlet of the air is 29 inches. One square inch of water one foot high weighs 0.434

pounds, so 29 inches is equivalent to 1.069 pounds per square inch.

This figure therefore has to be taken from the gauge reading of the air in the air supply header on the tank to find the cubic feet of air delivered into the can from the following table:

FLOW OF AIR THROUGH AIR INLETS TO CANS.
Flow expressed in cubic feet per minute.

Diam. in	Gauge Pressure in Air Header—Pounds.				
Inches	1.	2.	3.	4.	5.
1/64	0.027	0.038	0.046	0.052	0.059
1/32	0.107	0.153	0.188	0.215	0.242
3/64	0.242	0.342	0.471	0.508	0.545
1/16	0.430	0.607	0.750	0.857	0.965
3/32	0.97	1.36	1.68	1.93	2.18
1/8	1.72	2.43	2.98	3.42	3.86
3/16	3.86	5.42	6.71	7.21	8.71
1/4	6.85	9.74	11.9	13.6	15.4
3/8	15.4	21.9	26.9	30.4	34.6
1/2	27.	39.	48.	57.	67.

These figures show, if the pressure gauge is read at the blower, considerably more volume of air than gets into the can. For instance, leaving out length of pipe from blower to tank, friction, etc., air at 4 pounds at the blower cooled 40° will only have an effective pressure of 2.66 pounds when applied 12 inches from the bottom of a 300 pound can.

There is a direct relationship between the mineral salts in the water and the volume of air required. The process of freezing consists of the formation of small crystals of pure water in the form of ice. As the crystal forms, the soluble mineral salts being more soluble in the unfrozen water than in the ice, are removed by the unfrozen water. This happens with mineral salts truly soluble in water. Most waters contain, however, carbonates of lime and magnesia which, in themselves, are insoluble in water. In the presence of free carbon dioxide, however, by attaching to themselves one molecule of carbon dioxide they become soluble. The carbon dioxide becomes "half bound" to the carbonate molecule in the process. During the formation of the crystal of ice the half bound molecule becomes free and the carbonate of lime or magnesia contained in the small quantity of water becoming crystallized, is precipitated. The air agitation sends the small bubble of carbon dioxide gas to the surface where it passes into

the atmosphere. It behaves just like the air dissolved in the water does when the water being frozen is agitated. If sufficient free carbon dioxide still remains in the unfrozen water, the liberated carbonate is redissolved. If there is not sufficient carbon dioxide remaining it is precipitated.

Most waters contain an excess of carbon dioxide and as the small bubbles liberated by the process of crystallization are easily detached from the ice crystals, clear ice is obtained readily with good agitation.

The following data, obtained in earlier experiments, will bring out the effect of mineral salts on the clearness of the raw water can ice first made in a 300 pound can.

Mineral Substance	Grains per Gallon	Ice Made	Grains Mineral Subs. in ice made	Percentage of reduction	Remarks.
				%	
Calcium Carbonate	50	Clear	1.6	96.8	Usual agitation.
" "	75	Clear	1.9	97.5	Ice cloudy till more agitation was used.
" "	100	Cloudy	8.4	91.6	Ice cloudy with occasional clear spots.
Calcium Sulphate	15	Clear	2.2	85.3	Usual agitation.
" "	20	Clear	2.6	87.1	Usual agitation.
" "	30	Clear	3.7	87.5	Increased agitation.
" "	40	Clear	4.6	89.1	All the agitation possible.
Magnesium carbonate	7	Cloudy	5.8	17.1	Magnesium hydrate found in ice.
" "	10	Very cloudy	8.8	18.0	Opaque spots in ice.
" "	12	Opaque	9.8	18.5	Marble ice with full agitation.
" "	15	Opaque	11.9	20.9	Marble ice with full agitation.
Magnesium sulphate	5	Cloudy	4.2	16.1	Full agitation used.
" "	7	Cloudy	5.9	15.7	Full agitation used.
" "	10	Very cloudy	8.4	16.0	Full agitation used.
" "	12	Opaque	9.9	15.1	Full agitation used.
" "	15	Opaque	12.5	16.6	Full agitation used.
Sodium Sulphate	250	Opaque	364.0	....	Distinct crystals of Sodium Sulphate in ice made.

Taking as our standard 0.65 cubic feet of air per minute in each 300 pound can, this quantity is safe for a water not exceeding four grains of total solids per gallon. High magnesium salts make the water unsuitable for raw water can ice under any conditions. The increased air required is shown in the following table for a standard 300 pound can.

Mineral Salt.	Safe limit of ordinary agitation. Grains per gallon.	Increase in cu. ft. per minute for each grain per gallon above safe limit.
Calcium Carbonate	5	0.055
Calcium sulphate	3	0.035
Magnesium carbonate	3	0.065
Magnesium sulphate	1	0.080

These figures were obtained for waters made up to contain pure salt solutions. With mixed salts as shown in a natural water it is safe to drop the initial air margin to 0.5 cubic feet per minute and then make the additions. For Croton water this would figure 0.66 cubic feet per minute.

The usual considerations for magnesium salts still apply, namely, that a water high in these salts is unsuitable for raw water can ice.

The relationship between the rate of freezing, as shown by the brine temperature was next taken up. As shown before the process of freezing liberates gases—air and carbon dioxide—and in the concentrated core some mineral salts. To prevent these being frozen into the ice, agitation is required and the more numerous the matter to be removed, the more air is required. The rate of freezing is retarded by the formation of ice on the inside of the can, but the water still unfrozen becomes more concentrated, so the balance remains undisturbed. I have found it best to allow 0.015 cubic feet of air per minute for a 300 pound can for each drop of 1° F. below 14° F. in the brine.

It must be remembered that under any circumstances raw water can ice will concentrate its solids into the center of the can and therefore unless a water extremely low in solid matter is used, the core should be withdrawn and refilled with fresh water. The matter in suspension acts just exactly the same way as matter in solution and therefore efficient filters should be used, preferably installed in duplicate so that the filters can be properly cleansed.

A disk type of filter or some form of filter with removable filtering material should be used. A filter does not work by magic, and if it arrests matter in suspension, that matter in suspension will accumulate and clog the filter, destroying its efficiency. The matter caught by the filter must be from time to time removed.

CONCLUSIONS.

No. 1. The pressure gauge on the air for agitation should be placed on the air header on the ice tank in addition to a gauge at the blower.

No. 2. A 300 pound can for water containing approximately 4 grains of total solid matter per gallon, requires 0.65 cubic feet of air per minute.

No. 3. When making can ice from waters containing an excess of four grains of solid matter per gallon, an allowance should be made to increase the agitation in accordance with the quantity and variety of solids as shown in the preceding table.

No. 4. Extra agitation should be provided when the speed of freezing is increased. In a 300 pound can the extra amount of air required when a brine lower than 14° F. is used, is approximately 0.015 cubic feet of air per minute for each degree below 14° F.

No. 5. Waters that are not suitable for the making of raw water can ice should not be used for this purpose.

No. 6. If a water is relatively low in sulphates, but relatively high in carbonates, the carbonates can be removed and the water made suitable for raw water can ice. If, however, the sulphates are high, an effective purification is not a commercial possibility.

DISCUSSION

President Neff.—After hearing Mr. Sparks' very interesting paper read, I cannot help but think how manufacturers in this country are prone to run into experiments and attempt things without any previous analysis. They venture to make raw water ice without investigating the character of the water available. I will ask Mr. Sparks how he determined the quantity and pressure of the air used in his tests.

John C. Sparks.—I did it by means of a gauge on the header, using different openings to get different amounts of air. For instance, referring back to the table on the flow of air through inlets to cans, if the pressure is taken as near the outlet as possible, those figures are relatively correct. I checked up one or two of

them, using an aspirator to start with, but in the ordinary experiments on different waters, containing different solutions, I took that table to be correct, if the pressure gauge was near enough to the outlet. If the pressure gauge is far off, at the other end of the plant near the blower, then this table is not accurate, and one almost has to guess as to the amount of air delivered. I think you will find, that the amount of air provided in most plants usually is not quite sufficient where a quarter inch injection pipe is used. With four or five pounds pressure at the blower, usually enough air gets into the can, but not if the pressure at the blower runs down to three pounds, and where a special nozzle is used on the end of the pipe, the opening there is apt to be very small.

President Neff.—Aside from pressure, how did you determine the quantity of air?

John C. Sparks.—At first I used an aspirator and checked my openings by collecting in same for a certain length of time. Afterwards I abandoned the aspirator.

President Neff.—For noting variations in pressure, do you find the ordinary dial gauge satisfactory?

John C. Sparks.—No, it is not very satisfactory, although the gauges I used agreed with a third gauge. Still I believe they deteriorate quickly. However, I did not thoroughly investigate that phase of the subject.

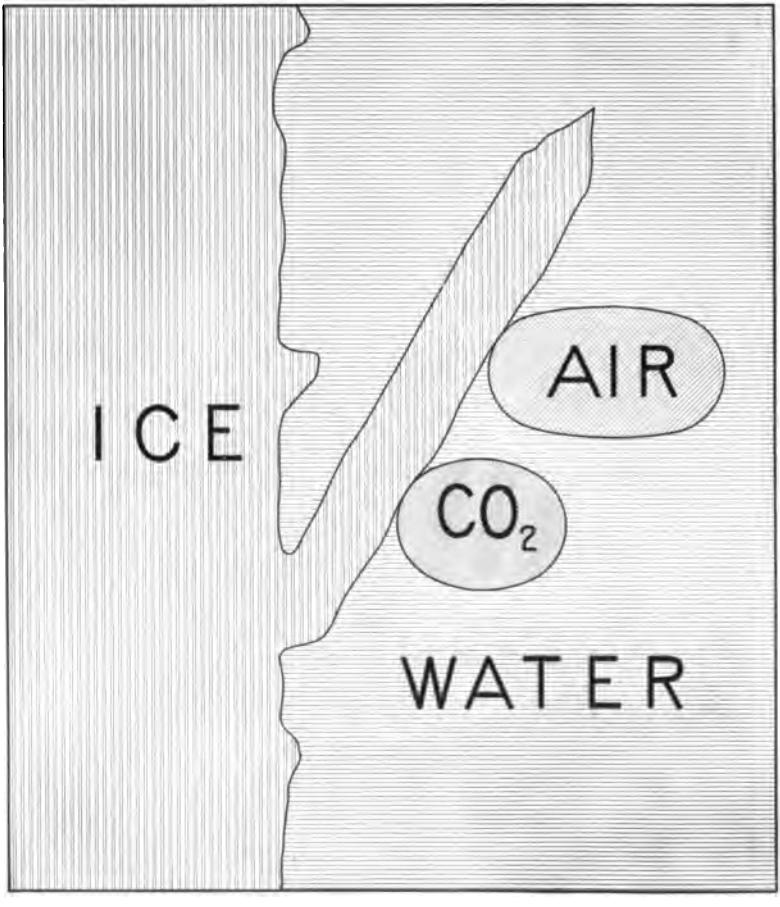
Van R. H. Greene.—If we have to have six cubic feet of air for each 300-pound ice can used in a plant, the compressing of the air will require tremendous power. I recall a quotation from the Bury Compressor Co., in which they asked for ten horse power for every 450 cubic feet of air per minute compressed against five pounds pressure. On that basis, there would be required twenty horse power for every 1,000 cubic feet. Thus, in an ordinary ice plant of 200 tons capacity and 3,000 ice cans, there would be required 18,000 cubic feet or somewhere around 300 horse power for blowing the air.

John C. Sparks.—The figures must be twisted somewhere, Mr. Greene.

Van R. H. Greene.—Ordinarily we figure that it takes only half a cubic foot of air per can, and that is bad enough.

John C. Sparks.—Using what sized opening?

Van R. H. Greene.—About one-sixteenth of an inch. Mr. Sparks speaks of having an air gauge at the header. The only



ELIMINATION OF DISSOLVED GASES IN PROCESS OF FREEZING.

Van R. H. Greene.—Croton water. I was just going to ask if you did not think it is a matter of mechanical conditions as well as chemical?

John C. Sparks.—To a certain degree, yes, but the more matter you have in solution, the more agitation you require.

Van R. H. Greene.—If you have a can of Croton water and will take the time, purely as an experiment, to keep changing the length of the tube continuously from ten inches from the bottom when the ice is starting, up to a point within six inches of the top of cake, you can get almost a clear crystal cake all the way through on half a cubic foot per minute air circulation per 300-pound can.

John C. Sparks.—Croton water is an almost ideal water to work with. You don't get that, however, when you go away from New York.

Van R. H. Greene.—But, even with Croton water, if you wait until the injection pipe reaching within ten inches of the bottom is about to be frozen in, and it is removed and the core water sucked out and replaced by fresh water, you will get a heavy mandril at the center of the cake, because, from that point on, the agitation is interrupted. Hence, it seems to me that the question of continuous agitation throughout the entire freeze is all important.

John C. Sparks.—I agree with you, it is particularly a question of mechanical conditions, but more attention ought to be given to the relative amount of agitation.

Henry Torrance, Jr.—I have made a rough calculation: Six and a half cubic feet of air a minute per can at fourteen cans to the ton of ice, at three pounds pressure per square inch, is 38,700 foot-pounds per minute, approximately, or, about one horse power per ton of ice would be the work of agitation alone!

John C. Sparks.—I find the error in my figures is due to the decimal point being in the wrong place. It should read 0.65, not 6.5 cubic feet.

John E. Starr.—I happen to have a concrete case in mind—a plant making 58 tons of ice. The blower has a rated capacity of 300 cubic feet of air per minute, the receiver pressure is three pounds; the water is better than Croton water and the ice made is very good.

Van R. H. Greene.—How much horse power does it take?

John E. Starr.—I figured it up from the electric bill, deduct-

advantage of a gauge at the header would be to show the pressure represented by the distance of submergence of the pipe in the can, unless that opening were restricted. If restricted, would it not be better to enlarge its area rather than increase the pressure at the header?

John C. Sparks.—I think one is as good as the other, so long as you get enough agitation. Referring to that table, you will find that you can get exactly the same thing both ways. You can have a lower pressure and a bigger opening, or you can have a higher pressure and a smaller opening.

Van R. H. Greene.—The idea is to have an opening sufficiently large to carry the proper number of cubic feet of air to each can after the pressure required to overcome the submergence has been reached.

John C. Sparks.—Yes, a little over one pound is the pressure of submergence. No, I wouldn't put it that way; you have the size of the opening according to the pressure of air the blower delivers at the tank, which pressure is different from that at the blower.

Van R. H. Greene.—Oh! yes, I appreciate that.

John C. Sparks.—So you make the size of your opening in relation to the actual pressure of air.

Van R. H. Greene.—If you did that, you wouldn't have anything but the one pound pressure of the air pipe.

John C. Sparks.—Why ?

Van R. H. Greene.—Because, unless you restrict the opening at the header, you cannot carry a higher pressure than that due to the submergence.

John C. Sparks.—Certainly; I am only considering this in the small openings; you can only have a small opening in an ice can. About a quarter of an inch is the usual size and just about what is required; for instance, at two pounds pressure, with a quarter inch opening, you get five cubic feet per minute. You say you use what, Mr. Greene?

Van R. H. Greene.—About half a cubic foot to the can.

John C. Sparks.—What size opening do you use?

Van R. H. Greene.—A sixteenth of an inch opening at the restricted orifice of quarter-inch tubing. You get about five pounds pressure at the blower and a little over one pound of submergence.

John C. Sparks.—That would be just under a cubic foot a minute. What water was that?

ing for the electric lights and some other motors from the total bill, I estimated that the power on that motor was between 12 and 15 horse power.

President Neff.—How many cans have you?

John E. Starr.—I think there are 600 cans in the tank.

President Neff.—Then you have only about half a cubic foot of air to the can.

John E. Starr.—Yes. But that water was very good; I don't think it could be taken as anything to go by generally.

Louis Block.—Mr. Sparks, the quantity of air used for a plate plant is very much less. Do you know what it is per ton of ice?

John C. Sparks.—No, I do not, but it is much less, for very good reasons; there is such a lot of space in which to circulate in a continuous movement all the way up the plate, and then there is a large amount of water remaining unfrozen; making it quite a different proposition.

No. 121

ELECTRICITY FOR ICE MAKING AND REFRIGERATION AS SUPPLIED BY THE CENTRAL STATION

By C. H. Stevens, Brooklyn, N. Y.

(Non-Member of the Society)

As this Society represents the authorities on ice manufacture and refrigeration, and as the question of electricity as a motive power for this industry is receiving considerable attention at the present time, particularly as to its economic application to plants of the larger capacities, it seems pertinent that a paper should be presented here, giving for your consideration the central station viewpoint on the subject.

Before an engineering body such as this, it is not thought necessary to elaborate upon the motor itself as a motive power. It is doubtful if there are any of your members but who do accept it as being the proper method of drive, wherever it may be applied. However, there may be some present who do not consider that the motor may be applied for the operation of large ice making and refrigeration units with commercial success—not that they have any misgivings as to the mechanical efficiency of such an equipment, but that they do not consider it would be a success from an economic standpoint. For this reason, this paper will dwell principally on the question of rates as adopted by the central station companies and the application of these rates to this particular business.

Of course, the principle of all central station rates is generating costs, plus distribution costs, plus a profit. The sum of these three items must be less than that at which the same amount of energy may be produced in your plants, in order that the installation of central station service may be an economic success. For it to be a desirable contract from the central station viewpoint, these three items must be included in their rate at a fair and reasonable valuation.

Accepting this situation, we must first ascertain if the central station companies are in a position to include these three items in a contract that represents a price for current delivered to a large refrigeration or ice machine at a net price at or below that for

which this power may be manufactured in those premises by private means.

GENERATING COSTS

Taking up first the question of generating cost in the power station, we must consider that a central station company is in business primarily to manufacture electric current. The operation of their power plants is a science which, with them, is usually carried to a higher degree of refinement than is the case with the operation of the private plant. The great amount of current which they manufacture warrants their employing the best engineers obtainable and purchasing the most efficient apparatus manufactured. The initial investment of a power plant is only limited by the economies which it can produce, and it is perfectly justifiable to replace, with new apparatus, expensive units, which may be comparatively new, if this should show a percentage of fuel economy which would be so small as to be unnoticeable in the smaller private plants. For example, in our own generating station the loss due to one inch of vacuum maintained on one of the condenser pumps of our largest sets has been found to be approximately $15,000 per year. With a detail such as this, having so distinct a bearing upon the costs, it must be obvious that in the successful central station, the engineering efficiencies must be developed to a higher degree than in the smaller plants. The fuel problem is so studied out that the maximum work is obtained with a minimum amount of cost. Coal is purchased by some of the larger companies under contracts which call for upwards of 500,000 tons per year. The generating stations are located on the water front where coal may be delivered directly to the stations in boat loads and put into the bunkers by the most economical and efficient coal handling apparatus, and where river water may be used for condensing purposes. Single generating units in some of the larger stations run as high as 15,000 or 20,000 kilowatts, and are generally of the turbine type.

Turbine pumps also usually furnish power for the auxiliaries and show much greater economy over the ordinary steam pumps used for this purpose in the smaller plants. Also these larger units are connected directly to a certain bank of boilers and auxiliaries so that the entire operation of that set is distinct and separate from any other except for the switchboard connections. With this arrangement the load adjuster in the central station may so adjust the load on the system as to keep each unit loaded to very nearly its

full capacity, or when the load falls off to any appreciable extent upon one unit, the remaining load is divided up on the other units, and the first unit is shut down. By this arrangement in the stations of the Brooklyn Edison Company each unit in operation throughout the day is carrying an average load of approximately 80% at which point the higher efficiencies are obtained.

The labor item per unit of power generated in the central station is very materially less than in the private plant, for while the class of labor employed in the larger station is necessarily of a higher type, the proportional amount of labor that goes into each unit of power generated is at least 75% less than in the smaller plant. All of these conditions are conducive to low generating costs and it is believed that a careful consideration of them will convince any engineer that a certain amount of power may be generated in a central station to an appreciably lesser degree than that same amount may be produced by private means under ordinary conditions.

DISTRIBUTION COSTS.

The current generated in most stations is alternating high tension, and is distributed with these characteristics to its several sub-stations or distributing points, where it is either transformed to a lower voltage for commercial use or is changed to direct current by use of rotary converters. The distributing cost of this high tension current is extremely small owing to the high voltage used. When one considers that in some parts of the country high tension current is distributed a distance of 150 miles or more with approximately 5% loss, he must plainly see that the distribution cost of this main current supply in the larger cities is a minor consideration, and that its bearing upon the rates for which current may be sold, if taken directly from this high tension feeder system, is so small as to be almost negligible.

PROFIT.

It must be understood that a central station company is in business to sell a service, and that when a contract is taken it is with the assumption that that service will be permanent. The percentage of profit for this commodity supplied is extremely low as compared to what it would be necessary to make if they were selling a piece of apparatus whereby the sale would be completed upon its installation. The profit must be so determined

as to show a reasonable return on the service for such time as it will be used.

With the generating costs reduced to the lowest degree obtainable, and the distribution cost a minimum consideration, it is but logical that current may be sold to a large refrigeration or ice making plant directly from these high tension feeder systems at a cost below that for which the same amount of power could be made on the premises, and still show a reasonable margin of profit for the central station companies. There are also conditions peculiar to the ice making and refrigeration business which have a distinct and definite bearing upon the price at which current may be sold to plants of this nature.

FIRST—The load factor* of refrigeration and ice making is exceptionally high, which makes it particularly desirable from the central station standpoint.

Second—Practically all of the central station companies have a large peak load on their generating stations a few hours each day during the Winter months. This peak load is occasioned by the day load or power load, overlapping the night load or lighting load. It usually occurs between the hours of four and nine o'clock p. m. during November, December, January and February.

To take care of this peak load a large amount of generating apparatus must be carried in their generating stations, which may not be used to any great extent during the rest of the year. The fixed charges on this additional equipment have a slight bearing on the total generating costs of such current for the year, as is used during this peak period. While the amount of this item has no effect upon the statements previously made as to the comparative cost of making current, it does have a bearing upon a further economy which may be effected in an ice making or refrigeration plant, operating electrically. That is, the same hours during the year that the central station has this peak load are the least important of any during the year to the ice plant or refrigeration plant, as the outside temperatures are sufficiently low to reduce the full 24 hours' use of the large compressors. Therefore, if necessary they may shut down these large compressors during this peak period and may do so without in any

*Load factor: Ratio of average load to maximum load on basis of 365 days per year, 24 hours per day.

way handicapping their business, as they can still make their full quota of ice.

SYSTEMS OF CHARGING FOR CENTRAL STATION SERVICE.

The majority of central station companies have a system of charging for electric service based upon a *primary* or *readiness to serve charge* and a *secondary* or *operating charge.*

The primary charge is made to cover the fixed charges on the generating equipment in their stations, and the service wires and meters which are installed for that particular customer. This charge, of course, remains constant as it exists whether or not there is any current actually used. As the amount of this primary charge is in direct proportion to the capacity of the service supplied, it is based upon the greatest amount of current which will be used at any one time, and is called the Maximum Demand. After these charges have been met, current may be sold for the actual cost of generating, plus a reasonable percentage of profit, which constitutes the secondary or operating charge. As the cost of this current generated is dependent upon the amount used, discounts are usually allowed on this secondary charge in proportion to the total consumption, or the greater the amount used, the greater the discount.

By a careful analysis of this system of charging, and referring to the statement previously made that the load factor of refrigeration and ice making is exceptionally high, it will readily be seen that this business gets the full advantage of such rates, or automatically earns a materially cheaper rate than the average industrial concern. Where such rates as these do not apply with economy for the operation of the larger refrigeration and ice plants, it is simply a question of the central station companies adopting a rate for current to be used directly from their high tension feeder systems during such hours as do not appear upon their peak load for the year, and basing this rate upon reduced distribution and generating costs. With this system of charging for off peak business, a provision is made in the contract whereby the customer may operate a percentage of the equipment during the peak period sufficient to take care of the lights and auxiliary apparatus, therefore making it necessary simply to shut down the large compressors.

Up to a comparatively short time ago some of the larger ice making plants were making ice from distilled water and

obtaining a greater part of this distillate from the exhaust of their engines. They therefore, did not, with these conditions, consider that any rate that a central station company might offer them would be of interest, owing to the large amount of boiler capacity which they would still require to furnish their distilled water. However, this handicap has been obviated by the use of multiple effect evaporators in this type of plant. With this efficient piece of apparatus, in some instances as high as 50 tons of distillate per ton of coal are obtained with an 8 effect evaporator. This makes it entirely feasible to drive the compressors and auxiliary apparatus electrically, and to produce this distilled water economically by the use of the evaporators. The raw water system of making ice practically eliminates the distilled water question except for a small amount used in refilling the core, and, in some of the modern plants of this type, even this feature has been done away with, and the entire cake of ice is made from raw water.

Both types of plants being at the present time distinctly within the field of central station service, the matter is purely an economic question—the figure at which such companies are willing to sell current—determining whether or not it is the proper power for an ice plant to install. The best evidence that several companies have met the issue fairly is the fact that there are in this country to-day at least 15 ice making plants of over 90 tons capacity, and probably as many more refrigeration plants of as large capacities, which are operating entirely on central station service, and have been running for a sufficient length of time to prove their economies over other methods of power generation.

Some companies may not up to the present time have put into force rates which apply specifically to this business. However, the condition exists whereby they *may* do so and, if they have not already, it may be because they have not had the proposition put fairly before them. The attention of those of you who are interested in the installation of apparatus for this industry is especially directed to the fact that comparisons should not be made between the price per kilowatt hour paid by the average industrial concern, and that for which power may be purchased for the ice making and refrigeration business.

Each case should be presented before the central station company fairly and judged upon its individual merits alone.

APPLICATION OF MOTORS TO THE EQUIPMENT.

The adaption of the electric motor to the large compressors is mechanically simple.

Chain or rope drive is generally used for the larger units, and the motor supplied should have a speed of under 500 r.p.m. for a proper drive to the standard type of compressors used. As alternating current service is supplied in most instances, motors should be of the slip-ring or wound rotor type on which the standard ratings of efficiency run as high as 95%. On this type of motor there need be no revolving surfaces in contact, with the exception of the bearings, which reduces the maintenance of the apparatus to a minimum, and to this is largely due the fact that their economical life is longer than that of any other type of prime mover. In several of the modern plants now installed where two or more units are used, constant speed motors have proven a decided success. If constant speed motors are installed in the first place, and after that it becomes desirable to have variations in speed, it is simply a matter of adding additional resistance to the existing equipment.

For auxiliary apparatus, motors directly connected to the machines are recommended, except in some few instances where exceptionally low speeds on the machines are necessary.

The figures in Table No. 1 and Table No. 2 were taken from actual operating conditions in different parts of the country.

Table No. 1 gives refrigeration data with particular reference to the kilowatt hours per year per cubic foot of cooler capacity.

Table No. 2 gives data on large ice making plants operating electrically with particular reference to the kilowatt hours per ton of ice manufactured.

TABLE I.

REFRIGERATION DATA.

Wholesale Meat Markets.

	City	Connected H. P.	Tons	Cu. ft.	Kw. Hrs. per year	Kw. Hrs. per year per cu. ft.	Temp. of cooler	
1	Philadelphia, Pa.	15	8	22,980	25,728	1.12		
2	" "	10	6	15,732	30,448	1.93		
3	" "	25	15	21,384	42,636	2.00		
	Ave. kw. hrs. per year per cu. ft.					1.68		
4	Chicago, Ill.	30	12½	23,190	30,456	1.31	20°F.	
5	" "	10	7	7,690	14,880	1.93	20°	
6	Pittsburgh, Pa.	50	20	94,000	159,250	1.69	30°	
	Ave. kw. hrs. per year per cu. ft.					1.64		
	Packers.							
7	Chicago, Ill.	30	15	4,340	6,000	1.38	36°	
8	Pittsburgh, Pa.	30	15	39,680	76,292	1.93	36°	
10	New Orleans, La.	30	15	54,500	51,372	.944	35°	
	Ave. kw. hrs. per year per cu. ft.					1.41		
	Provisions.							
11	New York, N. Y.	15	8	10,505	23,412	2.24	36°	
12	" " "	10	4	38,880	25,783	.665	38°	Makes ice
13	Chicago, Ill.	15	8	8,820	12,204	1.38	41°	
	Ave. kw. hrs. per year per cu. ft.					1.43		
	Retail Meat.							
14	Philadelphia, Pa.	15	8	3,000	9,949	3.3	35°	
15	New Orleans, La.	7	2	1,490	4,600	3.1		
16	Chicago, Ill.	15	8	4,629	26,808	5.8	36°	
17	" "	5	2	1,706	3,408	2.0	43°	
18	Philadelphia, Pa.	7½	4	2,500	11,099	4.45		
	Ave. kw. hrs. per year per cu. ft.					3.73		
	Fur Storage.							
19	Brooklyn, N. Y.	39½	20	56,775	19,760	.35	30°	
20	New York, N. Y.	7½	4	5,722	1,931	.34	20°	
21	" " "	15	10	33,120	23,000	.70	16°	
22	" " "	30	15	40,500	27,321	.67	32°	
	Ave. kw. hrs. per year per cu. ft.					.51		

TABLE II.

PLANT NO. 1.

City, State.....Chicago, Ill.
Business.....Manufacturers of ice.
Process.....Distilled water can system.

Running hours per week, 168.

Rated daily capacity of plant in manufactured output, 120 tons ice.

Actual output during the year covered (8 months) 32,500 tons.

KILOWATT HOURS FOR 8 MONTHS.

1912	Kw. Hrs.	1912	Kw. Hrs.	1912	Kw. Hrs.
May	117,000	Aug.	216,700	Nov.	152,445
June	190,000	Sept.	205,802	Dec.	160,619
July	211,000	Oct.	204,312		

Total connected hp. (additional 100 hp. added in 1913) 564
Total number motors installed..... 20
Average kw. hrs. per month..... 182,239
Kw. hrs. per ton of manufactured product..... 44.7

INSTALLATION.

All motors wound for 230 volt, 60 cycle, 3 phase.
2-200 hp. motors belted to 2-50 ton compressors.
8- 2 hp. motors on 8 agitators.
1- 75 hp. motor, on 1 deep well pump.
1- 40 hp. motor on 1 centrifugal water pump.
2- 5 hp. motors on 2 centrifugal brine pumps.
1- 10 hp. motor on 1 elevator.
2- 1 hp. motors, belted on 2 cranes.
1- 3 hp. motor on 1 coal hoist.
1- 3 hp. motor on 1 mechanical stoker.
1- 3 hp. motor on 1 coal conveyor.
1-100 hp., 720 r.p.m. motor, operating 1 air compressor for pumping water (added in 1913).

PLANT NO. 2.

City, State.....Buffalo, N. Y.
Business.....Manufacturers of ice.
Process.....Distilled water can system.

Running hours per week, 168.

Rated yearly capacity of plant in manufactured output, 32,850 tons ice.

Actual output during the year covered 33,002 tons of ice.

KILOWATT HOURS FOR 12 MONTHS.

1912	Kw. Hrs.	1912	Kw. Hrs.	1912	Kw. Hrs.
Jan.	92,530	May	139,550	Sept.	160,250
Feb.	65,080	June	145,686	Oct.	154,090
Mar.	71,870	July	157,640	Nov.	76,460
Apr.	133,550	Aug.	156,700	Dec.	91,210

Total connected hp..... 427
Total number of motors installed..... 14
Average kw. hrs. per month..... 120,384
Kw. hrs. per ton of manufactured product..... 43.77

INSTALLATION.

All motors are 3-phase, 25-cycle, induction, either 2200-volt or 440-volt as follows:

2200-Volt Motors.

2-175 hp., 500 r.p.m., variable speed motors, each belted to 1 vertical duplex, single-acting, 45-ton (ice), 72 r.p.m. ammonia compressor.

440-Volt Motors.

1-25 hp., 750 r.p.m., variable speed motor belted to 1 condenser pump.
1-10 hp., 750 r.p.m., variable speed motor belted to 1 pumping out pump.
4- 5 hp., 750 r.p.m., constant speed motors, direct connected to brine pump agitators.
1- 5 hp., 750 r.p.m., variable speed motor geared to 1 soft water pump.
1- 5 hp., 750 r.p.m., variable speed motor geared to 1 boiler feed pump.
1- 5 hp., 750 r.p.m., variable speed motor belted to 1 distilled water pump.
2- 3 hp., 750 r.p.m., variable speed motors, operating cranes.
1- 1 hp., 750 r.p.m., constant speed motor belted to 1 water softener.

PLANT NO. 3.

City, State.....Chicago, Ill.
Business.....Manufacturers of ice.
Process.....Raw water can system.

Running hours per week, 168.

Rated capacity of plant in manufactured output, 120 tons ice per day.

Actual output during the year covered, 27,839 tons.

KILOWATT HOURS FOR 12 MONTHS.

1912	Kw. Hrs.	1912	Kw. Hrs.	1912	Kw. Hrs.
Mar.	76,600	July	237,500	Nov.	71,308
Apr.	97,100	Aug.	224,000	Dec.	32,001
May	127,300	Sept.	192,551	Jan., 1913.	48,447
June	167,300	Oct.	112,419	Feb., "	68,486

Total connected hp	511
Total number motors installed	*11
Average kw. hrs. per month	121,251
Kw. hrs. per ton of manufactured product	52.2

INSTALLATION.

1-150 hp., 3 phase, 60 cycle, 230-volt, 514 r.p.m., slip-ring motor, belted to 1 60-ton compressor.

*1-300 hp., 3 phase, 60 cycle, 230-volt, 514 r.p.m., slip-ring motor, belted to 1 120-ton compressor.

1- 2 hp., 3 phase, 60 cycle, 230-volt motor, belted to 1 agitator.

2- 15 hp., 3 phase, 60 cycle, 230-volt motors, belted to 2 air compressors.

1- 2 hp., 3 phase, 60 cycle, 230-volt motor, direct connected to 1 distilled water pump.

2- 1 hp., 3 phase, 60 cycle, 230-volt motors, direct connected to 2 vacuum pumps.

2- 10 hp., 3 phase, 60 cycle, 230-volt motors, on 2 condensers.

1- 5 hp., 3 phase, 60 cycle, 230-volt motor, direct connected to 1 hoist.

In conclusion, central station power as applied to the smaller refrigeration and ice plants, has been accepted as being the proper drive in practically all plants of medium and small capacities. The vital question before this industry at the present time is the application of this same power to the larger and more important plants. Whether or not it will be installed in these plants will, to a great extent, be decided by the members of The American Society of Refrigerating Engineers, and it is hoped that the points brought out in this paper have fairly put before you the relationship between the central station and this important science, and that they may have their proper bearing with you when these questions are at issue.

*Denotes operated separately.

DISCUSSION

President Neff.—Mr. Stevens' paper is very interesting; the subject is one that I think most of us are pretty deeply interested in at the present time. I was very much interested in his statement on the first page in which he says, "this paper will dwell principally on the question of rates as adopted by the central station companies and the application of these rates to this particular business." I was in hopes that I would get some information as regards rates. Mr. Stevens further along states, "by a careful analysis of this system of charging, and referring to the statement previously made that the load factor of refrigerating and ice-making machinery is exceptionally high, it will readily be seen that this business gets the full advantage of such rates, or automatically earns a materially cheaper rate than the average industrial concern." Then he goes on and shows us how he gets at it and says he is going to give us the rates, and when I got to the tables I thought I was going to find just what I wanted, but I do not find any large plant in New York City or Brooklyn listed, and I do not find any rates. Now, Mr. Stevens, if you can enlighten us on what it costs in different sized plants and under different conditions, you will confer a great favor on many of us. We do not ask your absolute rates, but if we had something to go by it would enable us to decide whether or not electric power should be put in. If we go outside of New York City—and a good many of us live outside of New York City—and approach the electric companies in our town, they say "Well, what are they charging down in New York City? We understand they have a lot of electric driven plants running." Of course, they probably know more about it than we do, but they want to get it from us. The consequence is that the electric drive has not been developed as fast as it should have been, principally because most of us are not sufficiently posted as to what the electric company is willing to do, and if you can help us a little on that, I would be obliged.

C. H. Stevens.—I will answer at the end of the discussion.

C. G. Armstrong.—I am very much interested in Mr. Stevens' paper, and I am heartily in favor of using motors in the case of refrigerating plants, but I have not found the rate satisfactory in some cases. I think, perhaps, it would be well to review the situation as regards current purchased from the central station, and furnishing one's own electric or steam power.

The cost of a central station plant is more than that of an isolated plant, so that the kilowatt cost, when reduced to an item of interest per annum, is against the central station plant. The cost of distribution in the case of a central station plant is larger because they have long distances to transmit the current. One item which seldom enters into the calculation is the item of lost, strayed or stolen current. The current starts out on the switchboard wth all the energy and hopefulness of youth, and much of it is lost. The meters reach out their arms in vain, to grasp the little volts that never come. They are lost—they have wandered from the straight and narrow path of their conductors and have destroyed themselves. This loss amounts to sometimes as high as 50 per cent. of the current generated. In the case of other plants, it might be as low as 20 per cent., but I doubt whether it is ever much less. This current may not be lost on the individual high tension line that runs to your plant, but somewhere in the dark labyrinths of the under surfaces, leaving only a spot of rust to tell the sad tale. It is lost in the whole network of wires that runs all over the city and are interconnected, hence becomes a charge on the ledger of the operating company and finally it must find its way to the debit side of your books.

I believe in the electric motor very much. I have used it in refrigerating and other plants. I would like to use it in all refrigerating plants, but there are some items—one is the transmission of power from the motor to compressor—that are a very serious matter. I have one plant where I put on a chain drive and found it very unsatisfactory. A rope drive, as Mr. Stevens says in his paper, is good, but that can only be used on very large compressors. If we had compressors running at about 500 revolutions per minute, it would be a very simple proposition. The whole question after all centers on "what can you sell the current for," and each of you gentlemen are competent to figure that out for your own plant. You know what it costs you to put in engines and boilers, or your engines, dynamos and motors, as the case may be. You know that during a good part of the year the exhaust steam, if not going into a condenser, can be used to heat the building in which you operate. Very often your ice plant is a part of some apartment house or hotel, where the steam passing through the refrigerating plant is simply on its way to heat the building and the refrigerating machine then acts merely as a reducing pressure valve. The

operating cost, Mr. Stevens says, is less in the case of the central station, and that is undoubtedly true—that is, so far as their plant itself is concerned, but that does not take into consideration a large and very expensive selling force, which is required to go out and convince the people against their better judgment that they ought to take current from the central station. All of this must be charged up to the cost of operation and has just as much effect on the cost of current when it gets to you and comes out of your check book as though it were coal or any other item of expense. I believe in extending the service of central stations. There are many ice plants driven by engines instead of motors, there are small installations and other cases where the machinery should by run by electricity, but in most plants I am inclined to believe that your own equipment will do it better and cheaper.

F. L. Fairbanks.—Perhaps I can give a little information in regard to the rates that might be obtained from a large company like the Edison Company, of Boston, which should be able to deliver current at a favorable rate.

About two years ago I was approached by their special representative with a proposal to take over our Eastern Avenue plant and to furnish us current through a transformer at a flate rate; that is to say, they would furnish us current for our power station at Eastern Avenue and our seven warehouses in that immediate district which are supplied from that power house. While we have a very large plant of our own, the matter was taken up with the idea that if they could furnish current cheaper than we could, it was a business proposition which we might be very glad to accept. We studied the matter very carefully and measured our load, both our peak load and our regular load, which, by the way, does not allow of shutting down at any time during the twenty-four hours in our service, and found that our demand would be equivalent to 10,000 horse power, which is probably more than any plant considered in this paper would demand. In other words, our Eastern Avenue plant is prepared, at any time, to serve a total of 10,000 horse power in our refrigerating, electric power and lighting service. In our large warehouses the refrigeration is handled entirely from coil rooms through the cooling rooms and freezing rooms by motor driven fans; so that we might as well shut down our compressors as to shut down our motors.

For this service of supplying 10,000 horse power, at a flat rate, so that we could use the current as we wished, the best terms that they could arrive at, after about six months of negotiating, was two cents per kilowatt hour. The Edison Company, of Boston, is supposed to be in fair shape to compete with any concern in a city of like size, and we were rather staggered when we were confronted with a rate of two cents per kilowatt hour, for the reason that we are already producing our own current for three-quarters of a cent per kilowatt hour on our electrical end, and including our large compressors we are getting down perhaps under that.

Without question we are generating steam as economically as the Edison Company, and we buy our coal just as cheaply; we are right on the water front and so we handle it as cheaply; we have as good equipment as they have, stokers, etc., and we consider our personnel fully equal to theirs; so that under those conditions we consider that right now we are doing about three times as well as they could possibly do by us, and so under the circumstances we refused to accept their proposition.

The matter was again taken up by them of their own volition, some six months later. Their object, possibly, was the advertising advantage gained if they could get our plant. It was assumable that, under those conditions, they would quote us as low a price as it was possible for them to quote and do business. In looking into the matter we found that, while undoubtedly they were generating at a very low rate, considerably under half a cent per kilowatt hour, it cost them about three times as much to distribute as it did to generate. Unless the central station company's load is pretty thoroughly concentrated, they have an immense amount of copper which is under-loaded most of the time and on which they cannot concentrate the load. They can concentrate the load on their engines and dynamos in the power house by cutting off units when the load drops to a point where they are safe in cutting out one large unit, although you can readily see that, with a central station having 15,000 kilowatt units, there must be a point when one 15,000 kilowatt unit is being held in service at a rather low efficiency. We know that when the load drops off to a point where they are working under a 15,000 kilowatt unit capacity, we will say, at least down to 50 per cent., they must keep that unit in service or they must undertake to overload the other units. As a matter

of fact, the practice, in the stations with which I am familiar, is to keep a unit in service until the load has dropped to a point where it is considered absolutely safe to carry the load with one unit less. Necessarily, during quite a proportion of the time the central station is not working at its maximum efficiency. I may say that we have exactly the same opportunity in compressor stations equipped with a number of compressors. If we considered it wise, we could readily cut out one compressor and overload one or two units, but actual practice has shown that that is not a safe thing to do. The overloading has resulted in destruction more times than it has in economy.

The rate of two cents which was quoted us by the Edison Company will give you a fair idea of what a central station can do for you, and that was on a basis of 10,000 horse power to be at our service twenty-four hours a day, for we can not cut out for anybody's peak load. Our compressors are working twenty-four hours a day, 365 days a year, and they have to do that to maintain temperatures within a degree or two, which we do at all times, barring accident.

John E. Starr.—It seems to me that this is not a matter for engineers to discuss; it is simply a question of bargain and sale. I know, for example, that in Buffalo the number of kilowatt hours per ton of ice made is 43.77. I know that to be the fact, and any well designed plant will require between 43 and 50 kilowatts per ton. I think every one of us knows how much it costs for coal in our particular locality, how much it costs for depreciation on our boilers, how much for firemen and such other engineering force as we would need over and above what would be needed in an electrically driven plant, so it appears to me to be simply a question of dollars and cents. I think we all have very definite ideas as to what we can produce ice for in various plants, under different conditions; we have got it figured down pretty close. Hence it is not a question of the cost of their coal or the manner of operation of their plants; it is a question of how much per kilowatt in each place they are going to sell current for under these conditions; I don't see anything else in it.

F. L. Fairbanks.—Another matter which might well be kept in mind is the power factor, not referred to in this paper, but which is a very serious item, especially in alternating current plants. In a plant composed chiefly of motor load, the power factor is com-

monly assumed as 90 per cent., but we do know that the power factor has dropped to 80 per cent., and under some conditions I have made tests and found it to be 70 per cent. In one city I found the power factor to be as low as 60 per cent. lower than it should be, but I think there is no station with a mixed motor load claiming a power factor better than 90 per cent., and it will average nearer 85 per cent. under ordinary conditions. This means that your motor is getting but 85 per cent. of the current passing through the meter, effectively, minus the actual efficiency of the motor, which may be 80 or 85 per cent. of that.

Charles H. Herter.—On the question of rates I might say that the president of the Eastern Ice Association, W. H. Dohrmann, stated at our recent Chicago meeting that in the Bay Ridge Ice Manufacturing Company's plant, Brooklyn, N. Y., a 150-ton raw water plant, he was getting current at about eight-tenths of a cent per kilowatt hour. At that rate it seems to be quite an attractive proposition.

Edward N. Friedmann.—I would like to add to that, that Mr. Dohrmann has to pay a minimum charge of $18,000 per year to start with, and after that he gets certain rates which may go down to the rate just stated.

C. H. Stevens.—That minimum charge of $18,000 a year does not affect the contract because their demand exceeds that amount. If I may answer all these questions now, I will do so.

First, answering you, Mr. Chairman; as to the cost per kilowatt hour of current—this paper is written on behalf of the Edison Electric Illuminating Company, of Brooklyn, and is generally typical of the rest of the central station companies. We are not authorized to quote the rates of these other companies, and, therefore, the paper dwells on the principle of rates rather than the rates themselves. We are fortunate tonight in having present Mr. Jones, the general sales agent of the Edison Electric Illuminating Company, who makes our rates, and I am going to ask him, after I have finished, to give a short talk on the principle of rates. In regard to the Bay Ridge plant in Brooklyn, Mr. Herter's figure is approximately correct and Mr. Jones will explain the principle of the contract given that plant.

Mr. Armstrong referred to the loss from the motor to the compressor by using a chain drive, I believe that loss can be brought down as low as from two to three per cent., however, in

the majority of larger plants, the engineers are recommending the belt or rope drive—they claim that they get as high efficiency with that as with a chain.

In regard to distribution costs, it seems there is some misunderstanding. This paper applies principally to the larger plants where current is sold from the main high tension feeder system of the central station company. The paper states that some of the larger stations in the West transmit current 150 miles at approximately 5 per cent. loss. At the Bay Ridge plant in Brooklyn, the feeders are run directly from our nearest generating station; the current is 6,600 volts and the loss is very small indeed. Mr. Armstrong, I think, had reference to the loss due to secondary distribution, where we distribute direct current at low voltage; this does not apply in any way to the larger plants which this paper deals with. Mr. Fairbanks also made reference to power factor as affecting the central station generating costs; this, of course, is avoided through the use of synchronous motors which obviate the power factor to a great extent. Mr. Fairbanks spoke of getting a rate of two cents in Boston for 10,000 horse power. I do not know both sides of the question, but even if such a rate of two cents were granted there that does not signify that you cannot do better in some other cities. We would like very much to have that Boston plant brought to Brooklyn and we would quote a decidedly lower rate than two cents.

C. G. Armstrong.—Would you like to have all the ice plants brought to Brooklyn so you could do that?

C. H. Stevens.—We surely would, Mr. Armstrong. I believe I have answered all the questions except those that bear on rates and Mr. Jones will talk to you on that subject.

John L. Plock.—As Mr. Starr says, it is only a question of how cheap you can purchase the current, the best bargain you can make, but unfortunately a great many, in fact, the majority of the plant owners accept as a fact the salesman's statement as to the economy of operating with central station current. There is an ice plant in Brooklyn paying a two-and-a-half cent rate, making about sixty tons of ice per 24 hours, with a current charge of from $0.80 to $1.00 per ton. When you come to add that to the fixed charges, depreciation, and the wages of the operators, I don't believe we have to look very far to find out what will happen to this plant should the price of ice get down to $2.00 a ton next

season. I do not think any rates I have seen published, rates of the Edison Company or any other company, with the possible exclusion of hydro-electric plants, show as good economy as does a high class compound condensing unit, such as is being built by some of the foremost engine builders of the United States.

President Neff.—We will now be glad to hear from Mr. Jones, the rate man of the Brooklyn Edison Company, and I want to say to Mr. Jones that Mr. Stevens has a very interesting paper containing a great many points. If you could just give us an idea of what it costs to operate some of those plants from your station, it would serve a very useful purpose for the rest of us. There are some cases that are all figured out with the exception of the rates; what will they be?

T. I. Jones.—One year ago in Brooklyn we had no ice rate and there were no ice making plants on our system. Just about that time we got in connection with the ice people and after investigating their load curves we said to them: "Your business is making ice; ours is making power. If we can sell you power as cheap or cheaper than you can make it, there can be no reason why you should run your own power plant." You will all grant this is a reasonable premise to start with.

One of the previous gentlemen, Mr. Fairbanks, has said the electric central station rates is based, to a large extent, on distribution. Another feature of central station rates is generating cost or plant cost, and a third is composed of such charges as are included in the necessary office force. Now, if you will let me represent by a straight line the months of the year, starting with January and ending with December, and show on this diagram each month the central station load, which is highest in January and December, and lowest in July and August, we will get a curve of our output something like Fig. 1. Most ice dealers—possibly the Boston gentleman is an exception—have their smallest output in January and December and their largest output in July and August. The January part of the curve represents the fixed charges on our plant since it represents the money that we must pay for generating apparatus. If we can find use for that generating apparatus through this summer valley of the curve, we don't need to figure on any fixed charge and I can leave that cost out of the question of the rate, thus eliminating one of the largest elements of cost in our plant. We can sell, therefore, all the cur-

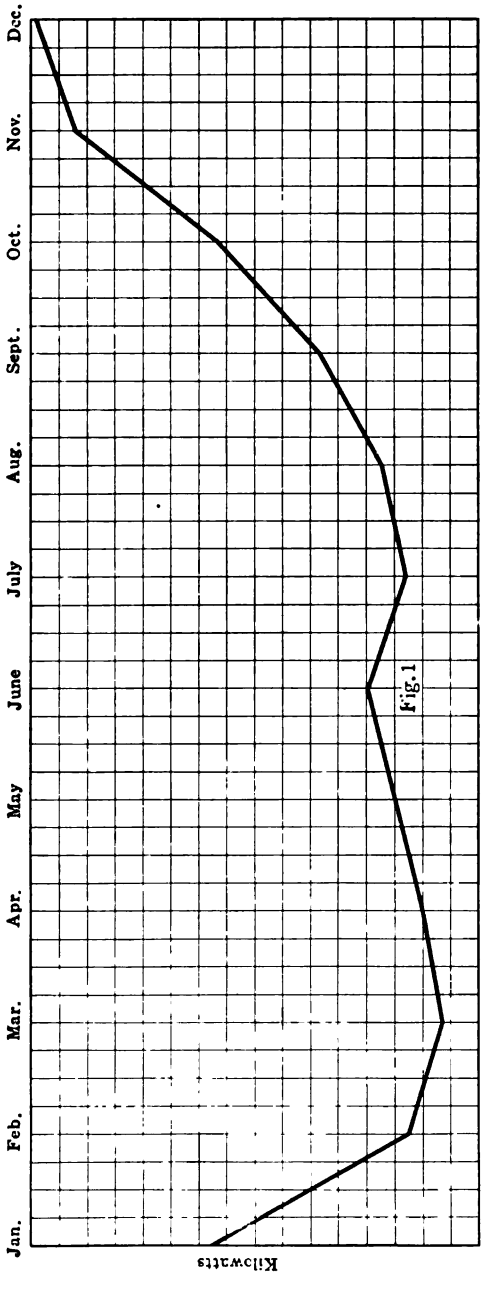


Fig. 1

rent in this summer valley at a rate which would cut out the fixed charge portion of the cost. The distribution cost which one of the gentlemen spoke about, can also be eliminated, because as a rule current for an ice plant is sold at high tension on a feed line close to a generating station of the company. Most of the loss in distribution is in secondary mains, as the copper loss therein is largest. That is eliminated in selling high tension current without the secondary distribution. So we have then a proposition of selling current to you who have a load usually when we have not, and which load falls off when ours comes on. In short, other things being equal, we can make our own plant do two things, run our peak in the winter time and run your load in the summer time, and the cost of the plant is on the peak of January and December. Your Chairman has asked the specific question, for what can we sell current. We have adopted a sliding scale of rates. We start off with $80.00 per kilowatt of demand per year, $75.00 for another step and $70.00 for another step per kilowatt per year. Now, if you multiply your kilowatt demand by the rate per K. W. demand and divide by the number of kilowatt hours used in a year, and you have a 100 per cent. load factor, as has the Boston gentleman—you will obtain a rate less than a cent per kilowatt hour.

The question was brought up that in Brooklyn the power cost the Bay Ridge Ice Manufacturing Company to begin with, $18,000, and in addition eight-tenths of a cent per kilowatt hour. Here the $18,000 was a guarantee of so much business and the cost of the current was included in that $18,000 and not added to it; in other words, the $18,000 was merely a guarantee that we would get $18,000 worth of business at the rate per kilowatt the Bay Ridge plant would earn under the terms of their contract. Each step of the ice rate has its own minimum yearly charge based entirely on the capacity and use of the ice company desiring the current. If you had your own plant, you would have to pay your own fixed charge, you would have to pay for that plant whether you used it summer or winter and you would have depreciation to figure on, all of which we can eliminate in this method of charge.

Mr. Plock informs you that a certain ice dealer is paying two and a half cents per kilowatt hour in Brooklyn. I happen to know that the man is paying less than two and a half cents; but he is not on our lines and hasn't our rates. I think you will also agree that the very nature of your business is such that, with the peak of

your business coming where our valley is greatest, there is no logical reason why the central station should not give you a rate which, to use a common expression, can beat to a frazzle any private plant rate you can possibly earn yourself, and that the private plant is entirely out of the question if you are considering a raw water plant and where distilled water is not essential.

That, briefly, is what we have done in Brooklyn; we have tried to meet the ice dealers as they wanted us, and I think you will agree that there are conditions in your business not present in other lines of business which warrant the central station in giving you a rate commensurate with the use you put it to, that is, the utilization of central station machinery where otherwise it won't be used; or, to use another example, riding in a horse car during the time when traffic is lightest. Whatever you gentlemen want in the central station line within reason, I am sure the central station men will be glad to give you.

F. L. Fairbanks.—I would like to ask Mr. Jones if he speaks for the Edison Company, of Boston, when he says there is no logical reason why they should not quote less than one cent, and if he doesn't think they are in a position to quote as low as anybody in a city of equal size, unless they have a hydro-electric plant, assuming as I do, that their equipment is equal to any as it is now operated. Why do they or why did they not make a lower rate if they are willing to do so? In other words, as I understand Mr. Jones, the street car companies could carry you for a one cent fare when they were not crowded, if they wanted to, but they don't want to.

T. I. Jones.—That is exactly what I mean, as they would be glad to do it if there were any means of regulating it. If you were running a railroad whose cars were unfilled during the light hours of the day, wouldn't you take them on at any amount slightly over the actual running cost rather than running them empty?

F. L. Fairbanks.—Absolutely no; not as the manager of a business which is bound to pay its way and make a profit.

T. I. Jones.—I know, as a matter of fact, that the Edison Company, of Boston, sells current lower than two cents a kilowatt hour, and I am sure if you would say to them, as the Brooklyn ice dealers said to us, "We don't want your central station current merely as a standby in case our plant breaks down, but we will throw the steam equipment out and give you the business if you will

give us a rate which is as cheap or cheaper than our plant can produce." Under those considerations and with a reasonable guarantee for returns on the investment that they are obliged to put in, I am sure they will meet you just as we have met our Brooklyn friends.

F. L. Fairbanks.—Inasmuch, as this is a matter of facts and not theory, that was exactly the conditions under which this proposal was taken up, viz., that we should discontinue our steam plant in so far as operating it was concerned. However, we had no idea of junking it, by the way, but that we should discontinue our generating plant entirely and take all of our current for that particular section of our business from the Edison Company. There were no ifs and ands; there was no guesswork about it; our log showed exactly what our load was every hour in the twenty-four for a period of ten years, so that absolutely every detail of operation was before them. They knew exactly what they were to be called upon for every day in the year and every hour in the day, and the solicitation was entirely upon their part. After some six months of thought we discarded any idea that we ever had of using central station power, for the reason that within two months of the time that this matter was concluded they lost their entire Atlantic Avenue feeders, and that has occurred three or four times since, so that our plant would have been absolutely down and out under those conditions and we would have had no recourse. At the present time we have duplicating units with which we can handle the majority of our load. What I have said in regard to this matter are facts. We were dealing with the Edison Company, who presumably had a knowledge of the conditions at hand and I haven't any doubt but that they could furnish this current at one and one-quarter cent if they wished, and to eliminate their copper charge, in fact they have done that in a great many cases, and the legislature of Massachusetts has practically stopped it, so that it has become over there a very serious matter for them to make a special rate to one consumer and not meet it to another, so much of a matter that a bill has been before the legislature two or three times to regulate the price of current. That is the way we are situated over there; I don't know how it may be in Brooklyn.

T. I. Jones.—Before the last statement made gets fixed in the minds of the hearers, let me say that there is absolutely no question of discrimination whatever in this rate, none at all, but it so hap-

pens that the manufacture of ice has the characteristics to which I allude. It is not true in making shoes; it is not true in making woolen goods; it is not true of any other manufacture, except, as I now recall, the manufacture of paper and possibly of cement, and the same rate that we have quoted the ice people we quote to paper manufacturers, so there is absolutely no discrimination. There is nothing in any Massachusetts decision that prevents a load factor rate, as I have given it. It so happens that your business is more fortunate in its period of operation than the shoe makers and others. It is the operation of your ice manufacturing plants that makes it so favorable to the central station men to co-operate with you.

F. L. Fairbanks.—I assure you from my investigation that they will not catch us very quickly after what we know now.

Van R. H. Greene.—The Bay Ridge Ice Manufacturing Company's plant is of 150 tons daily capacity. If they run 200 days at full capacity, their output will be 30,000 tons of ice a year. That, on the basis of an $18,000 fixed charge amounts to 60 cents per ton. Assuming, as in the Buffalo plant, a current consumption of 43.77 kilowatts per ton of ice, which amount is much below the average, this would equal 1.4 kilowatts per ton. That they will sell over 30,000 tons of ice is not likely, because, as a rule, that is about the full yearly output of a plant of that capacity.

C. H. Stevens.—At Bay Ridge they figure on an output of 40,000 tons of ice per year, and that is a conservative estimate.

Gilbert H. Crawford, Jr.—May I ask about the operation of an ice plant with a constant speed induction motor? I suppose this type of motor, having no commutator, is the best for such a load. Must not that be run at a constant speed, because if the speed is varied there is loss in efficiency? I would like to ask Mr. Stevens what the effect of speed variation is on the efficiency of an induction motor.

C. H. Stevens.—I could not state exactly the variation, but I know that the efficiency of a motor at constant speed is much higher than when operated at varying speeds. I would like to ask Mr. Moore, of the General Electric Company, to answer that question.

W. J. Moore.—The efficiency of an alternating current motor is higher at constant speed than under variable speed. The difference between a constant speed and a variable speed induction

motor of the slip ring type is in the resistance which is inserted in the rotor. The resistance with a variable speed motor is of sufficient capacity to reduce the speed and carry the current indefinitely. This resistance stays in the motor while running under reduced speed, and occasions a loss of current. Thus the efficiency is lowered at reduced speed. The efficiency of a 300 horse power motor would probably be about 92 per cent. when operating under normal full load, while at 20 per cent. lower speed the efficiency may be 75 to 80 per cent. Thus there would be about 20 per cent. loss when operating under a 20 per cent. reduction in speed, depending on the size and normal speed of the motor.

President Neff.—All the current killed in the resistance is metered and must be paid for?

W. J. Moore.—Yes, the induction motor is not as well adapted to variable speed as is the direct current motor. We can give you 90 per cent. efficiency throughout any range of speed on a direct current motor of large size, but in an alternating current motor the efficiency diminishes as the speed is reduced.

C. G. Armstrong.—And the power factor?

W. J. Moore.—That goes down too, but not at such a great rate.

F. L. Fairbanks.—Representatives of the Westinghouse Electric & Manufacturing Company, Pittsburgh, tell us there is absolutely no such thing as a variable speed alternating current motor. We have about 400 motors in service, from 250 horse power down, and of different types. We have the F. & H. F., which is a slip ring type of motor,for our elevator service, and while the alternating current motor with the round roller can be slowed down for a short period of time, such slowing down is simply due to slipping, the voltage is not changed, it is a resistance in the secondary which handles the current at a low voltage. In order to get variable speeds our 140-inch fans, we were obliged to work out a design for a three-speed motor. We took a sixteen pole motor and arranged it in three groupings, of eight, twelve and sixteen poles respectively, to secure half, three quarters and full speed. In reducing the speed by means of a resistance in the secondary the efficiency drops off a good deal faster than the power, so fast that you will be surprised at the result in current consumption. We know of motors which the General Electric Company has put in for sewage pump service that are run on the grouping

principle, but, so far as introducing resistance in the secondary of an alternating current motor is concerned, it is absolutely impossible to produce a motor which will run continually at reduced speed without excessive heating. Any such motor running at other than a synchronous speed is slipping, and the efficiency of the motor varies almost in proportion to its slippage.

W. J. Moore.—Mr. Fairbanks is right about the two different types of motors. The resistance absorbs current the same as the resistance in a street car. Used in connection with a motor it absorbs a certain amount of current. The first type he refers to is called the slip ring type; the second, the changeable pole type. In the latter we can vary the speed of the motor by grouping the poles differently. That motor is more efficient under these speed changes, than the slip ring motor, but the different speeds obtainable are widely separated; that is, you can get a motor of that type to run at, say, 1,200 revolutions, 900 revolutions, 720 or 600, but it would run close to those speeds, you could not get any fine graduations of speed between those points. The efficiency at those speeds might be very high, but not as high as with the direct current motor. With the direct current motor it is possible to get those fine variations of speed and will keep a high efficiency.

Gilbert H. Crawford.—Does not a changeable pole motor have to be large enough and heavy enough so that with the reduced number of poles it can carry the full load of the refrigerating machine? It requires a certain amount of energy to turn a compressor over once no matter what the speed. So much energy is absorbed per revolution, and the motor has to supply that at whatever speed it is running. If a certain number of the poles are cut out, the normal power of the motor is reduced. I believe, therefore, that the motor with a variable number of poles would have to be large enough at the smallest number of poles to turn a refrigerating machine over at the greatest refrigerating load per revolution.

W. J. Moore.—It is a matter of design. A motor is built to meet the demand made upon it. The speed may be increased by using fewer poles, and reduced by increasing the number of poles. For your work a motor would have to be so designed that you would get enough power to operate your compressor on the low speed combination of poles. The efficiency would be different with the different pole changes, there might be a difference of two per cent., or 5 per cent.; one group of poles might be very efficient

and another group less efficient. Briefly, engineers have to take propositions of that kind and work them out, when it is a case of special design to suit special application.

C. H. Stevens.—In the Bay Ridge ice plant there is a 50 and a 100-ton machine, each driven by a constant speed induction motor.

F. L. Fairbanks.—I would like to reply to Mr. Crawford's question regarding size of motor, for the reason that we have come to the same conclusion and are about to discard all multi-speed motors on account of their inefficiency, notwithstanding the fact that this multi-speed or multi-grouping of poles require an excessive investment, a motor having to be large enough in its frame to carry the maximum load at the low speed, which makes it three times as large as a single-speed motor would be at the higher speed, and at about double the price. Another objection is, that at low speed the starting torque is very weak, hardly any power is being developed because one leg of one phase is short circuited, which means that if you get trouble on your phases out on your line, the motor is likely to become burned. We burned up a motor running at the low speed about a week ago, because we got a cross in one of our undergrounds and ran the voltage up between phases. The excessive cost of multi-speed motors is practically prohibitive. It does not give a variable speed, but three fixed speeds at which a compressor must be run whether you want to or not, and that is not economy in a refrigerating plant. Since these motors are not efficient enough, at the start or at any speed, we are going to discard all of them, not only in our fan system but in our power houses, on boiler feed pumps and on other service.

Karl Vesterdahl.—I would like to go back to the question of rates: I think that interests our engineers more than the different constructions in motors. Mr. Jones has drawn a curve on the blackboard indicating the variation in load from January to December. I would like to ask Mr. Jones if he ever considered a curve like that covering only twenty-four hours? A refrigerating plant ordinarily is operated twenty-four hours a day, but since a few years we are designing and installing a number of plants to be operated only twelve hours a day and less. In giving these users a rate, does the Edison Company take into consideration the user's load curve during the twenty-four hours? Suppose a plant were operated only eight hours a day, as from 8 a. m. until about 4 p. m., would that result in a rate lower than that applying to twenty-four hour operation?. My customers, I believe, get practically the same

rate whether their plants are operated twenty-four, twelve or ten hours a day.

T. I. Jones.—A rate is always gauged in accordance with the hours of use of current. As an analogy, if you used each of five horses two hours a day, you would pay a higher charge than if you used one horse ten hours a day. The same holds true in our rates. If you can so adapt your ice making so as to carry it over a long period of time, when our investment is lower in the central station, you get a rate accordingly. It is true that if you use a plant only six or eight hours a day, you pay a higher rate than if you used it twenty-four hours a day, because there are certain hours in the day that you don't use it.

Referring to the rate charged in Bay Ridge, we made that rate so low because the ice people said to us "We are going to operate this plant during the summer ice season virtually twenty-four hours a day," and we made a rate for them in accordance with that period of operation. Their work is ice making, not refrigerating, and their rate was made according to their conditions. Now, if you said to us, "I want the machine to go six or eight hours a day and I would just as soon take that six hours of current during the day time when you haven't got your peak," then we could make another rate equally attractive. What I want you gentlemen to appreciate is this, that the central station rate is based on fixed charges and cost of operation, and if you can adapt your operation so that it will not bring into consideration our fixed charges on our peak load at night, and can use the current during the time when the traffic is not heavy, we can make a rate merely based on the cost of making the current.

W. T. Price.—I arrived too late to hear all of this discussion, but I am told that the electric power costs the Bay Ridge ice plant a minimum of $18,000 a year, and that Mr. Jones does not think it possible for any other kind of power to compete with this. I would like to show you how one class of power can compete. We will take the case of the Bay Ridge ice plant operating two hundred days per year at full capacity, 150 tons a day. That would be 30,000 tons of ice per annum. The charge that must be paid is $18,000 a year.—

T. I. Jones.—That should be 40,000 tons, Mr. Price.

W. T. Price.—I am taking the average case where the annual output is equivalent to 200 days operation at full rated capacity.

We may find special cases where a plant will operate 365 days a year, but that is very seldom. I am considering an average, not a special case.

T. I. Jones.—Where do you find that guarantee of $18,000?

W. T. Price.—That is your minimum charge on this 150-ton Bay Ridge plant, is it not?

T. I. Jones.—We fitted the case to this plant on a basis of 40,000 tons a year.

W. T. Price.—Didn't you state that your minimum charge was based on the peak load?

T. I. Jones.—No.

W. T. Price.—You will surely admit that if this Bay Ridge plant did operate only 200 days per year the charge would be no less than your minimum, however, to avoid argument, we'll take it at 40,000 tons. An oil engine plant can be installed that will operate at a guaranteed fuel cost of seventeen cents per ton of ice, using Mexican oil at 3½ cents per gallon, such as can be purchased in New York City, Philadelphia, or many other large cities. It won't be necessary to go into details; this economy is being realized in actual service and manufacturers will guarantee it. Multiplying 40,000 tons by 17 cents we get $6,800. The attendance for the electrically driven plant and for the oil engine driven plant will be the same. In either case we must have an engineer. There will, however, be an additional charge for lubricating oil; we will say $200 for the year.

T. I. Jones.—They have no engineer at Bay Ridge.

W. T. Price.—How can an ice plant be operated without an engineer?

T. I. Jones.—It requires only a twelve year old boy to turn on the switch, that's all there is to do.

W. T. Price.—I think Mr. Jones considers an ice plant about the same as we would a machine shop; we start up the motor and it runs the shafting, but in an ice plant we have to run a refrigerating machine with that motor, and that machine and a few other ice plant details have to be taken care of. The 12 year old boy isn't old enough. Now we will put down $200 a year for lubrication; there's $7,000 a year which we must spend for fuel and lubricating oil with an oil engine, against the $18,000 a year we would have to pay to the electric company for 40,000 tons of ice: the difference is $11,000. Now, if the two plants cost the same, if we could put in the oil engine plant for the same cost as the electric plant, this would

be the end of the story; there would be a saving of $11,000 per year. But we cannot do that, it costs a little more to make oil engines than motors; the difference in the cost of the oil engine over electric motor installation will be approximately $30,000. We will therefore have to get an additional $30,000 in some way to install the oil engine plant. Interest and depreciation naturally suggest themselves.

I am going to look at this problem in the same way a business man or banker would look at it. I have proposed this thing to bankers time and time again and they have always concluded "That satisfies us." The gentleman who is going to put in the oil engine driven ice plant has to go to a bank and borrow $30,000, on which he will probably have to pay 6 per cent. interest. At the end of the first year he will therefore pay for the use of that $30,000—$1,800. He simply uses that $1,800 which he would have paid to the Electric Company. During the year he has paid out for fuel and lubrication $7,000, he then pays $1,800 for interest and this still leaves a remainder of $9,200. This he applies to reduce his loan. Taking $9,200, which is the year's net savings, from $30,000, leaves $20,800.

We have charged off $9,200—call it for depreciation, reduction of loan, or anything you choose.

At the end of the second year we will have to pay interest on $20,800, amounting to $1,248, so in the same way we will take the $11,000 which we have saved in the year's expenditures by operating the oil engine plant instead of the electric motor, and we will subtract from that the $1,248, leaving a net saving for the year of $9,752. In the same way as before this will be paid back to the bank and will reduce the debt of $20,800 down to $11,048. You can clearly see that at the end of the third year we will have to pay interest on only $11,048, or $662, making the net savings for the year $10,338, which can be used to practically liquidate the balance of the loan.

The proposition is simply this: Pay out each year $18,000, just as would be done if the motor were installed, but instead of paying it to our friend, Mr. Jones, we pay part of it for fuel and lubrication, part for interest on a loan of $30,000, and part each year to wipe out that indebtedness. At the end of the third year the entire debt will be practically liquidated and from that time on the ice company is in position to enjoy increased profits to the extent of $11,000 per annum.

No. 122

FRUITS—THEIR HANDLING AND STORAGE

By J. L. Hughes, North Yakima, Wash.

(*Associate Member of the Society*)

In presenting this paper, based on some of my observations during ten years' experience, on "Fruits—Their Handling and Storage," I do so in the hope that the members of this society will accept it simply as observations and suggestions and not as a scientific treatise on the subject. The greater one's experience the more he will find there is to learn about refrigeration, and should be less ready to draw conclusions.

Likely many of the engineers who may read this collection of observations will find little that is new to them, and to those I would say that I am writing from the viewpoint of an operator of an ice and cold storage plant.

FRUIT PICKING TIME.

The proper picking of fruit is of greater importance to the cold storage warehouseman than any other one step in connection with the picking, packing, hauling, storing, transportating and marketing of fruit. A mistake in picking too soon or too late can scarcely be righted.

PEARS.

An exception is pears, which are better, both for handling and for eating, by having been picked green, for as soon as a pear reaches a good commercial size it is ready to pick. Then by proper precooling and transportation they can be transported cross the Continent and even to European markets in first class condition. They should be wrapped in paper and packed firmly, as they stand a tighter pack than any other fruit. The pears that come in for special consideration in cold storage work are the Bartletts, since they ripen in warm weather.

Pears, like peaches, ripen very quickly when removed from the trees. What happens during the first 24 hours after picking largely determines the life of the fruit, as the quicker they are placed under refrigeration, the greater is the arrest of the ripening process. Here is where precooling is most needed. The ripening processes during the first one or two days after picking

would be an excellent theme for some member to work out. It would throw light upon a stage in the fruit industry, the importance of which is not realized or appreciated by the average grower or shipper.

The average life of the Bartlett pears after picking is about thirty days. The Beurre D'Anjou pears, ripening later in the season and being more hardy, will keep much longer in storage.

SOFT FRUITS.

Soft fruits, such as cherries, plums, prunes, apricots, Yaki nines, nectarines, etc., need to be nearly ripe when placed in cold storage to be held for a better market. It is hardly practical to cold store such fruits if the market conditions are favorable.

If picked for storage they will stand to be a little riper than when picked for immediate shipment. The storage of such fruits for a month or a few weeks so thoroughly cools the fruit that they will have a longer life and a much better flavor than when picked green. Such fruits we cool as quickly as possible to 32° F.

When we receive a car load of such fruit and are obliged to put it into one room, we find it advantageous to place an ordinary electric fan in the room and direct the current from it constantly in one direction for a few hours to assist in establishing currents in the refrigerated air. This we also have done often with car loads of hot peaches. This is a good way to hasten refrigeration under the brine pipe system, which we use in one-third of our cold storage rooms. In the remainder of our building we use the fan system of circulation, with false floors and false ceilings for distributing and withdrawing the air.

PEACHES.

The peach is of great commercial importance in the Northwest. It grows luxuriantly, easily yielding a car or one thousand twenty-pound boxes per acre. The leading commercial varieties are the Elberta and Crawford, though many others are grown. The season's shipment of peaches from the Yakima Valley alone reaches a few thousand cars.

I do not hesitate to make the claim that by the proper use of precooling it is possible for the cold storage warehouseman to be able to greatly increase the successful distribution of peaches and so be of much benefit to his community in helping to successfully market the peaches already grown or to be the means of promoting a larger production.

Here is where the cold storage warehouseman crosses swords with many growers and with more commission men. The reason the precooling and the cold storage of peaches is so little employed at the present time is because it is not practical as the peaches are now ordinarily picked for shipment to distant markets, where they must be in transit from one to two weeks. The opinion seems to generally prevail that peaches must be picked green and hard—before they are fully grown, and with no ripening color— in order to have them "stand up" to reach a distant market. Though such a peach is undersized, and off color, it will stand up to cross the Continent if necessary, but it lacks flavor, the very quality that favorably characterizes our peaches that ripen on the trees. We have visitors from every clime, who, when they have tasted our ripe peaches off the trees, exclaim, "We never tasted such delicious peaches before. We don't get such peaches at the public markets." Here is where the cold storage warehouseman comes in. By a series of experiments by ourselves, as well as by grocermen, commission men and growers, we have found that peaches that are kept on the trees to mature, till they are full sized and well colored, yet firm, have as long a life as those picked green and in addition, *have the flavor* as well as the improved appearance. Besides, mature peaches will keep much longer in cold storage than those picked green.

Some years ago one of our grocermen, who knew what he could do with ripe peaches, bought all he could get of peaches considered "too ripe to ship," and stored them with us for from three to six weeks, till the "rush" was over, and put them upon the markets in this state at a handsome advance and in such prime condition as to bring him many repeat orders. Another customer of ours, a commission man, had two car loads of these "too ripe to ship" peaches and did not know what to do with them; as a last resort, he placed them in our storage at 32° F. for thirty days, then shipped them to Butte, Montana, a distance of 619 miles, and got a report back from the consignee that they were the nicest peaches and stood up the best of any that came to that market that season.

One of our fruit growers, W. W. Scott, made a visit to Illinois this Fall and took with him several boxes of ripe peaches, and the common expression from those who ate them was, "We never get anything like these when we buy peaches that are shipped here in car load lots."

One of Ohio's thinking professional men, Dr. H. H. Smith, who owns and operates a fruit ranch in this vicinity, and which is just coming into bearing, came out this Fall to take part in marketing his crop. He knew the results of marketing green peaches and so he left them on the trees to mature, and, as I have described above, he then shipped six car lots by freight without precooling to Ohio, but under refrigeration in refrigerator cars. The peaches were in such prime condition that he could sell them direct from the car, taking several days in which to do so, the peaches even then being in first class condition and the delight of all who purchased them. It is needless to add that his profit was much more than the average shipper of green peaches.

The State Fair of Washington is held in North Yakima annually. The fruit exhibit often covering two acres is termed by many, "The best in the country." Much of the soft fruits and peaches exhibited are held in cold storage for a month or more to await the Fair. In every case the ripe fruit is the specimen selected for the exhibit and the one that wins.

Another of our fruit growers, F. H. Russell, allowed his peaches to nearly ripen this season before picking for market; then had them precooled before shipment and realized very well on his crop. Some of his peaches became too ripe to ship, so he stored a quantity loose, equal to about 100 boxes, in lug boxes. These he took out in a month for cannery and home use. At the end of thirty days the very ripe peaches in the lug boxes had a better flavor than samples of his select stock of nearly ripe peaches.

The greatest drawback to the peach industry is lack of proper distribution. The orange, lemon and apple are so long lived that there is ample time in which to market them. The peach must be disposed of soon, a day too long on the tree and it is lost, except for local consumption.

The method of preparing peaches for the market has much to do with helping solve the more difficult problem of distribution. My suggestion is to let the peaches ripen, then pick, wrapping each in paper, and pack into a shallow box as soon as possible after picking; then haul direct to the cold storage where they are precooled, which process is described in another paragraph. After this they are ready for loading into refrigerator cars, in which, if properly re-iced en route, they will go to any market in the United States or Europe and be in marketable condition at destination.

PRECOOLING DESIRABLE.

S. J. Dennis, Expert on Refrigeration, United States Department of Agriculture, before the Second International Congress of Refrigeration in Vienna, 1910, speaking of the results of shipping precooled peaches from the Southern States to New York said:

"These experiments showed that the peaches could be allowed to become well ripened on the tree, and develop good flavor, and color, and, if cooled promptly after picking and packing, could be delivered in sound condition in the Northern market. Peaches so handled were distinctly superior in appearance and flavor to those which had been shipped in iced cars without precooling and which to compensate for the ripening which necessarily took place before the fruit became well cooled, had been picked in a less mature state. The brown or soft rot, which causes most all of the losses in the shipment of peaches, was greatly reduced in the precooled shipments."

Upon the same occasion Mr. Dennis said:

"During the maturing of a sound healthy fruit on the tree, certain chemical and physiological changes which constitute the ripening processes and which result in the development of desirable quality and flavor are constantly taking place within the fruit. After a certain point is reached, the fruit becomes overripe, flavor and quality are lost, and deterioration takes place; finally resulting in the destruction of the fruit either by decay, or through destructive physiological changes. When the fruit is removed from the parent plant and held at ordinary temperatures, these life and death processes continue. Warm temperatures hasten the ripening and breakdown; low temperatures retard them. It naturally follows that the promptness with which the temperature of the fruit can be lowered to the point where ripening will be checked or held nearly stationary, will materially influence the length of time that the fruit can be held in good condition.

"The germination of the spores in picked fruit is dependent upon proper moisture and temperature conditions. Germination does not take place while the fruit is dry or when the temperature is low. After the spores have germinated and the growth of the fungus has begun within the fruit, low temperatures (as low as 32° F.) do not wholly check its development. The prompt lowering of the temperature of fruit may serve either or both of two purposes:

"(1) The ripening is retarded and the life of the fruit extended:

"(2) If the temperature is quickly lowered the germination of the mold spores will be largely prevented and the fruit will arrive in the market in much better condition than is the case where it has been allowed to remain at a relatively warm temperature for some time after picking.

"Delay in the cooling of fruit susceptible to decay from mold results in the germination of the spores and the development of the fungus to a degree not effectively checked by the moderately low temperatures such as are obtainable in refrigerator cars by the use of ice alone."

Hence we see the importance of precooling. The refrigeration from the ice in the cars is not rapid enough to arrest these disintegrating processes in time to prevent the loss of fruit. Consequently the cold storage warehousemen are asking, "What can we do to improve the transportation conditions of soft fruits?" One of the answers is to precool them.

METHODS OF PRECOOLING.

There are two common methods of precooling: One is to assemble the fruit directly after packing in cold storage rooms. It is better not to pack the boxes too close nor too high in the room, as this will facilitate the refrigerating process. Electric fans, or an increased speed in the air circulating system, may assist in quickly refrigerating the stock. By this process we get the entire stock, thoroughly refrigerated to 32° in twenty-four hours.

If necessary, the boxes can then be piled closer together and additional stock placed in the same room. Ordinary cold storage rooms can be used for such precooling, especially by the assistance of additional air circulation in extreme warm weather when the stock comes into storage with outside sun temperatures, ranging around 90° F. This system of precooling is the best, and, where the fruit can be hauled in wagons to the storage plant, this is the system to employ, since it entails but little additional labor and furnishes much more thorough refrigeration.

The other system of precooling is the one that has given us the word "precooling," the *cooling before* shipment. This system was ably presented before this Society two years ago. My object in mentioning it here is to show that it is not a difficult task to add this equipment to any cold storage plant with necessary adjacent trackage.

By this process the car is first iced, then loaded with fruit, ready for shipment. Then it is placed adjacent to some cold storage plant equipped for precooling loaded cars. We have a brine coil room, or bunker room adjoining our loading track. This room we connect with the hatch over the ice tank on top of and at one end of the car by an insulated 18-inch chute. From the other end of the car a similar chute connects with the other end of the coil room. A large fan forces the air into the car, through the fruit and out at the other end of the car and back to the coil room to be recooled for continuous circulation. In from four to eight hours we have the air returning to the coil room as cold as the air that is going into the car, generally 32° F. Thermometers at either end and at the top and bottom of the car show the same temperature. This is about as thorough as the forced blast will do the work. Some systems have valves whereby the current of air can be reversed. Others deliver the cold air at the side doors and take it out at the ice tank hatches.

By our process we precooled a test car, thoroughly insulated, for the Northern Pacific Railway Co. to 34° at all points, then filled the bunkers full of ice. No more ice was placed in the car and at Minneapolis the car of pears were in first class condition, ice bunkers well filled and the temperatures at top and bottom of fruit and at center of car still showed 34°. The car was forwarded to Chicago, where the same conditions prevailed as at Minneapolis. The car was then forwarded to New York City, where the fruit was found in first class condition, but the temperature at the top of the fruit was 36°, while the temperature at the floor was 34°; one ice bunker was half full of ice and the other two-thirds full. This was in the early part of September. We are charging $20.00 a car for this service, but even at this reasonable rate few precool their fruit.

Most of the shippers still depend on the green fruit and ordinary iced car to enable them to market their fruit. But faith in precooling is gaining; it remains for every refrigerating engineer and cold storage man to keep everlastingly at it till the commercial advantages of precooling will become a commercial necessity. Most of our precooling is by the first mentioned process and our patrons have been highly pleased. Peaches, pears, prunes and summer apples have been the fruits mainly precooled.

APPLES—WHEN TO PICK.

All apples are picked green, ripe, or overripe, and the state of ripeness at picking time is the most important factor in determining the life of the apple in cold storage. Other factors influence the life, but I wish to emphasize the importance of right condition at the picking time. True, to get the best results with apples under refrigeration, great care should be exercised in the handling from the time of picking to storing. Our most successful patrons pick their apples ripe, placing them into cloth lined baskets or buckets. The apples are then placed by hand, or emptied from drop-bottom buckets, onto the sorting tables in order to avoid bruising. The grading and packing is also carefully done to avoid any injury to the fruit.

G. Harold Powell, ex-Pomologist in charge of Fruit Storage Investigations of the Bureau of Plant Industry, United States Department of Agriculture, in one of the department bulletins, has this to say:

"The ideal apple for keeping in cold storage is fully grown and highly colored, but still hard when picked from the tree. In this condition it has developed the most attractive style and finest quality and has attained the highest market value. An apple that is picked prematurely appears to ripen more rapidly than fruit picked in a more mature condition. Immature fruit deteriorates as quickly as or even more quickly than fruit that has reached a higher degree of maturity on the tree. The immature fruit is likely to lose in firmness in the warehouse and it is more susceptible to the development of scald."

WHEN TO STORE.

The best time to store apples is the next day after the apples are picked or as soon thereafter as possible. A delay of two weeks in getting the apples into storage after they are picked has been known to shorten the life of the apples one month. One customer brought us 5,000 boxes under proper conditions, the remaining 5,000 boxes of his crop he held in an ordinary warehouse pending better market conditions. After two weeks he concluded to store these under refrigeration. The following May the first lot went onto the market in good condition, no re-packing necessary. The second lot showed 10 per cent. deterioration. I should add that during the two weeks in the Fall when these apples were in the warehouse, we had warm weather. We find that uniform tem-

perature, averaging about 40° to 50°, is not so detrimental to apples stored for a week or two in ordinary warehouses, sheds or cellars as a variable temperature. Constant changes of temperature are fatal to the keeping of apples. Here is where cold storage has the real advantage over any other method, together with the uniform degree of humidity which cold storage affords.

RIPE APPLES NOT SO LIKELY TO SCALD.

Well colored apples are not so likely to scald as those with less color. This is but another way of saying that ripe apples will not scald as soon as green apples. To get fully colored apples many of our growers make three or four pickings of some of their apples, only picking the well colored and leaving the others to color. This does not take many days, since, at picking time generally, we have rather cool nights as compared with the days and these extremes of temperatures hasten the ripening, hence the coloring of the fruit.

Bulletin No. 144 of the Agricultural Experiment Station of the Iowa State College, Ames, Iowa, among other things, has the following to say on this subject:

"The results of the experiments would indicate that apples which are frozen in cold storage at temperatures of 24° F. or above would remain uninjured if thawed out gradually at a temperature below freezing, that is, at 29° to 31° F.

"In making the experiments, apples picked before they were frozen upon the trees, were stored in conjunction with apples from the same tree picked after two days of freezing weather, and in each case the apples that were frozen upon the tree kept better and showed less scald. This was supposed to be due to the fact that the apples picked before the freeze were less *fully matured* and that such apples are more susceptible to scald in storage than fruit that is matured and well colored." * * * "Well matured, well colored specimens scald very little while those immature and poorly colored suffer greatly."

Under the heading of scald the United States Department of Agriculture has this to say:

"Apple scald is not a contagious disease. It is a physiological disturbance not connected in any way with the action of parasitic or saprophytic organisms such as molds or bacteria. Briefly, it is the mixing of the cell contents or premature death of the cells and their browning by oxidation through the influence of

the normal oxidizing ferments of the cell. There are many conditions which influence the development of this trouble. It appears to be closely connected with the changes that occur in ripening after the fruit is picked, and is most injurious in its effects as the fruit approaches the end of its life. The scald always appears first on the green or less mature side of an apple, and if the fruit is only partly ripe it may spread entirely over it; but the portions grown in the shade and undercolored are first and most seriously affected."

WATER CORE.

Should we leave some of our apples on the trees too long to get the color, there is another danger, resulting sometimes from overripe apples, viz., water core.

There was a time when a rainy season or over irrigation was held responsible for water core. But that claim has long since been contradicted. Many trees having irrigating ditches on either side and within three feet of their trunks are known never to water core; other trees receiving but a small portion of the water usually put on an orchard have been known to have water cored apples. Last year a customer decided to cold store some Jonathans. In about ten days he brought in some more which had been in an ordinary warehouse during some rather warm days. In three months the latter showed water core, the former none. This season a few orchards of Winesaps showed water core. In each case observed they were off young trees, six and seven years old, and had been left on the trees too late in the season for such an apple. In one orchard the first picking showed no water core, while the last picking, two weeks later showed 10 per cent., not to any great extent, but perceptible. They became overripe and were water cored on the trees.

We notice that water core is seen chiefly in red apples. Since the red apple takes on so much red it is possible that they are the ones that are left on the trees too long and so get overripe, which seems to conduce to water coring.

In the case of the Jonathans mentioned above, it appears they became overripe by being left out of storage in a temperature that hastened the ripening. Hence, my claim in the first part of this paper; the most important factor in determining the life of the fruit in cold storage is to see that it is picked at the proper time. No rule and no time can be set for this. The dif-

ferent fruit districts of Washington pick the same variety of apple at different times, owing to different conditions. The different fruit states of the Northwest are each different from the results of observations and experiments in the middle west and Eastern apple states. Again, no two seasons are the same in the same district.

The warehouseman who is most successful in keeping his stock of stored apples for the season is the one who is the closest student of local conditions and who keeps in close touch with growers, who will co-operate with him in making such observations as will enable him to intelligently make recommendations to his patrons. The time has come when the cold storage operator must look beyond his warehouse platform, and the stock that is going into storage, if he expects it to come out in the spring sound and marketable without need of additional handling.

LIFE AFTER REMOVAL FROM STORAGE.

For some time after we ventured into the cold storage business we were confronted with the all too common remark, "Yes, fruit will keep very well in cold storage, but it will 'break down' very soon on removal from storage." We learned the fallacy of this statement by experience. We took Winesaps, Yellow Newtowns, Rome Beauties and White Winter Permains out of storage in May and asked our misinformed critics to take these home with them and report in two weeks or when the apples had "broken down." To their surprise the apples "stood up" for weeks. We sent Arkansas Blacks from cold storage in June to the St. Louis Exposition, and after being on exhibition for six weeks the apples were yet marketable.

Again we hear that apples from common storage will "stand up" much better than from cold storage. This has no foundation when the comparison is made at the same time of year. Too often the condition of the apple removed from common storage in January is compared with the cold stored apple removed in June.

The important caution for the cold storage warehouseman to make under this head is to be sure that the fruit considered went into storage at the right degree of ripeness, else the condition on removal from storage may be a disappointment.

FLAVOR AND AROMA.

Under proper conditions the flavor and aroma of fruit should improve in cold storage. But one must be careful not to make the observation immediately on the removal of the fruit. The test should not be made till the fruit has ripened. We have kept many apples for two years, and it was apparent that the older the fruit the more pronounced the flavor. This statement would not apply if the fruit came in green.

WRAPPED FRUIT.

Fruit keeps much better in cold storage when it is wrapped in paper. This applies especially to apples, peaches and pears. It very materially prevents the spread of decay.

GRAPES.

Ripe grapes are better stored immediately after picking, rather than to leave them out a few days for the green stems to dry. They keep the longest by being packed in odorless sawdust to prevent crushing.

VENTILATING.

It is not necessary to ventilate cold storage rooms full of fruit. The regular visits to read temperatures and remove stock affords sufficient ventilation. In many of our rooms back from the door a lighted match will scarcely burn with half the natural flame due to lack of oxygen.

Cold air, as cold as 20° F., can be blown on fruit for several hours without any fear of the fruit freezing. The first thing to do with fruit delivered for storage is to cool it, and as quickly as possible.

Practically all our fruits are in boxes or crates. We place two by four inch timbers on the floor under the fruit and place laths every two feet as we pile up the boxes, these afford additional spaces for the air to circulate and assist in making the pile rigid.

Under our direct brine system we have no point in a room that is more than eight feet from a brine coil. Temperatures are maintained uniformly at 32° F. for fruit.

NO MORE SUMMER APPLES.

When promptly stored the summer and early fall apples become winter apples and can be sold as such, if market conditions justify

it. Last year we held R. I. Greenings and Holland Pippins from September 13 to May 20, of this year, when they were shipped to New York and brought $2.75 a box of 50 pounds.

CONCLUSION.

Fruits under refrigeration owe their longevity largely to the condition of the fruit when picked, the care in handling and the time that lapses before storing. Success after that is easy if these three determining factors are favorable. To be sure of results the cold storage operator must use every means in his power to determine which, if any, of these three factors have been neglected in connection with the stock brought to him for storage. The more successful apples are kept, the less they can be sold for in the Spring and still meet the added expenses. The lower the price in the Spring the more will be bought. This will insure more business the following season and the cold storage warehouseman becomes the central figure in determining the success and growth of the cold storage business.

If the cold storage operator rises to his opportunity to-day, it is possible, through him, to place the distribution of the apple on a par with the distribution of the banana, on sale in every market the world over, at a reasonable and regular price. This done, then the pessimist who flaunts the cry of "over production of apples" must needs pull down his false banner for at least ninety-nine years. Then the apple, the preferred fruit, edible the year round the world over, will command the distinction it so well deserves—The King of Fruits.

No. 123

A REVIEW OF THE FEED SYSTEMS OF REFRIGERATING COILS AND THEIR RESPECTIVE ADVANTAGES

By Ernst S. H. Baars, Milwaukee, Wis.

(Junior Member of the Society)

With the development of the science of refrigeration and the different methods of its application, numerous devices have been designed to supply the refrigerant to the evaporating surface, called throughout this paper the refrigerator coil. Since the surfaces are of varied character, according to the service they have to perform, it is certain that the applications of the feed system are of the same or even greater variety, and this gives occasion for discussion, as only one arrangement can be perfect and advisable for a certain given arrangement of the refrigerator coil. I have already mentioned that the character of the refrigerator coil varies as to its service, and, to be able to intelligently treat my subject, it is desirable to include a mention of the arrangement of the refrigerator surface in this paper, because a feed system is one of the necessities of the refrigerator coil.

Because ammonia predominates as a medium for refrigerating systems, most improvements have been made in connection with apparatus in which it is used, but there is no reason why the same systems, as are used in connection with ammonia, should not be employed in modified form for the other refrigerants, as carbonic acid gas (CO_2) and sulphuric acid gas (SO_2).

The feed systems for the refrigerator coil may be divided into three groups—the force feed or direct expansion systems, the gravity feed or flooded systems and systems which are a combination of the two. In either of the above feed systems the refrigerant is admitted to the refrigerator coil by means of a regulating valve or cock. As everybody is familiar with regulating valves and cocks, as used in American practice, it seems to be unnecessary to dwell upon their construction. It may be mentioned, however, that cocks and valves are liable to clog up with dirt from the system. It is also practically impossible to so adjust a number of

expansion valves or cocks feeding from a main liquid supply pipe or header, as to obtain an equal supply of refrigerant to each refrigerator coil connected to same.

In Europe there is an appliance which overcomes most of the objections of the regulating cock or valve, in an apparatus which distributes the refrigerant to a number of coils of equal length by means of a revolving disc, which rotates over as many holes as there are coils. The disc has one hole which allows the refrigerant to enter each coil once during one revolution. Figure 1 shows a section of this apparatus in which A is the disc, showing the inlet hole or opening over one of the distributing openings, B, in the body, which holes are arranged in a circle to the same radius as the inlet hole, around the center of rotation. It is claimed that this apparatus makes a system 20% more efficient than that operated by ordinary expansion cocks or valves. This apparatus is also a very efficient oil separator. Doctor Linde, the inventor of this apparatus, is also the originator of a single rotating cock which works on the same principle.

These apparatus, and also the ordinary cocks and valves, may be controlled either by hand or automatically by temperature or pressure control, either of which arrangements may be found as a part of a refrigerating system.

In practice, refrigerator coils are fed in some cases from the top, and in other cases from the bottom, and the question often arises as to which is the proper way of feeding a coil. We find the two methods of feeding practically everywhere, in brine tanks, ice tanks, room piping and in beer coolers. In my estimation there is no reason for the existence of the top expansion system, because it has been found that it is not more efficient than the bottom expansion system, but, on the other hand, there is danger in operating it, as there is a chance of carrying liquid over to the compressor. The top expansion system has been employed mainly in connection with horizontal compressors where wet gas has been preferred for operation, also where the forecooling tank coil of an ice freezing system is so arranged that the return gas of the ice tank may pass through on its way to the compressor.

The bottom expansion system has been used by builders of vertical compressors, and in such cases where dry gas is essential for the successful operation of the compressor.

One system may be mentioned in this connection, which may be called a horizontal feed system. To my knowledge, it is con-

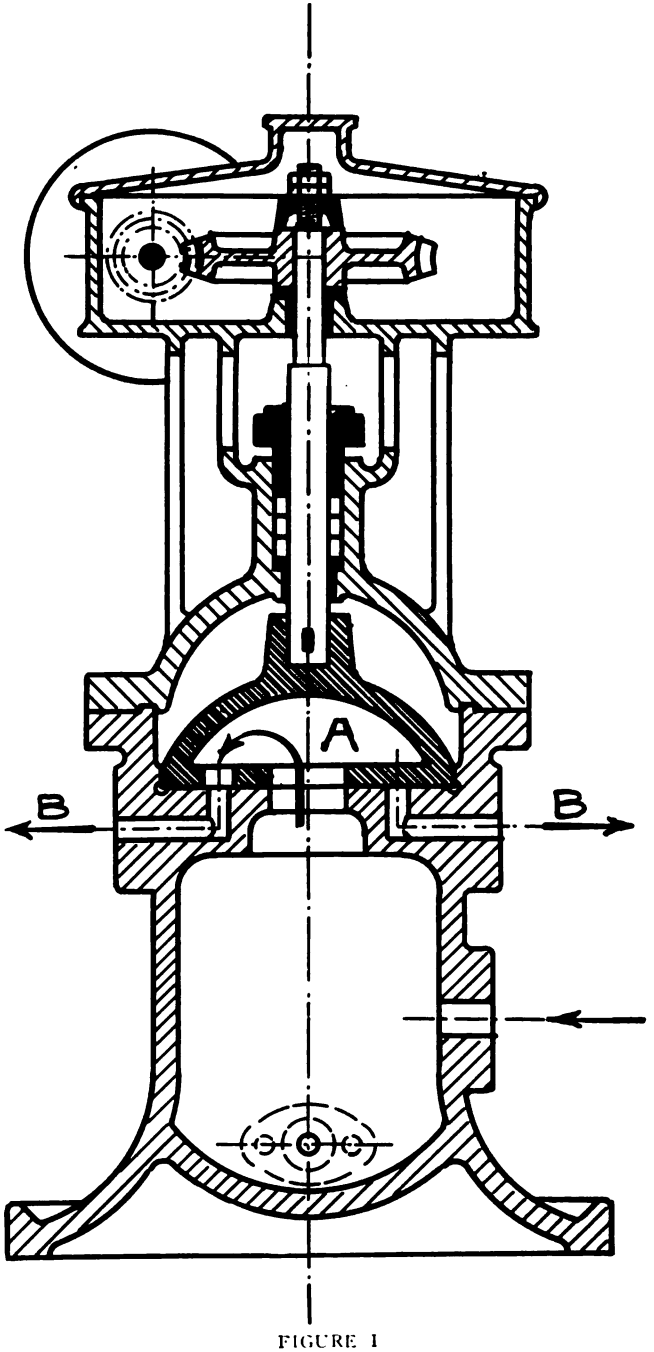


FIGURE 1

structed as shown in Figure 2. It is fed by one regulating valve only. One thing which I have not been able to learn is the reason for the existence of the part A in the suction manifold. I would have done away with that. This system is used in a can ice tank, and there is another similar arrangement for the same purpose, but in this case each horizontal coil has its own regulating valve.

The deficiencies of the force feed system, relative to proper feeding of a number of coils with one regulating apparatus or a number of coils with a regulating valve for each coil, are all overcome

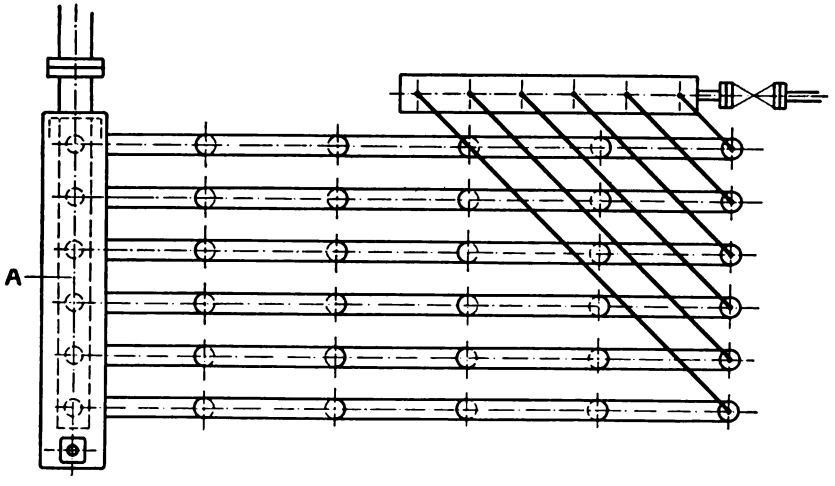


FIGURE 2

by the gravity feed or flooded systems, and, besides that, a greater part of the cooling surface is made efficient because the pipe is not needed as liberating surface. The invention of the first of these systems in this country dates as far back as the late eighties. Unfortunately the inventor, Mr. H. J. Krebs, was not encouraged enough with the results obtained during the first tests to satisfy him as to the merits of the new system, and consequently further tests were abandoned, the result being that the system was forgotten for years. Judging from the patent papers one must say that it was well designed and would well perform its duty today, but without the float operated regulating valve for ammonia. For sulphuric acid gas systems this float arrangement would probably have worked much better for the reason that with SO_2 a much larger quantity of refrigerant is required for the same number of heat units and which would not necessitate such a closely set open-

ing, and further because the difference in pressure between the incoming liquid and the refrigerator coil is about one-third of that in a NH_3 system. As far as I could learn the float arrangement was replaced by an ordinary feed valve, and in this shape the system was manufactured, at least during the last few years of the life of the patent.

Two other gravity feed systems are in use today in addition to the Krebs method. These have the same advantages as regards the facility of feeding a number of refrigerator coils at the same time. One system patented by the late Mr. H. Rassbach has, as a special feature, the precooling of the refrigerant for the purpose of preventing excessive spraying of the entering mixture of liquid and gas, the latter being created by the sensible heat of the refrigerant.

The third system, which I do not know whether is patented in this country or not, admits the refrigerant directly into the refrigerator coil and forces the gas, liberated by the sensible heat of the liquid, to pass through the entire coil. The unevaporated liquid is allowed in this system to return through a check valve. Whether this arrangement is an advantage over others or not should be determined by a comparative test. If the test would show equal results it would indicate to me that the disadvantage of passing more gas through the coils would probably be eliminated by a more rapid circulation, and therefore a better heat transfer. The increased speed would also give a higher back pressure at the inlet, and consequently a higher evaporating temperature. It would be necessary, in order to make this third system equally as efficient as the first two, that the more rapid circulation, and therefore more rapid heat transfer as mentioned above, take care of the losses due to the larger volume of gas in the coil and the higher evaporating temperature.

Gravity feed systems were also patented in Europe and the one patented by Schmitz in 1903 seems to be analogous to and of an earlier date than the third mentioned system. Figure 3 will give an idea of the construction. A represents the refrigerating coil, B the accumulator or separator, C is the check valve and D the feed valve.

Professor Pictet also used in his binary system of refrigeration an arrangement which might be classed as a gravity feed or flooded system. Including the headers, it is identical with the above-men-

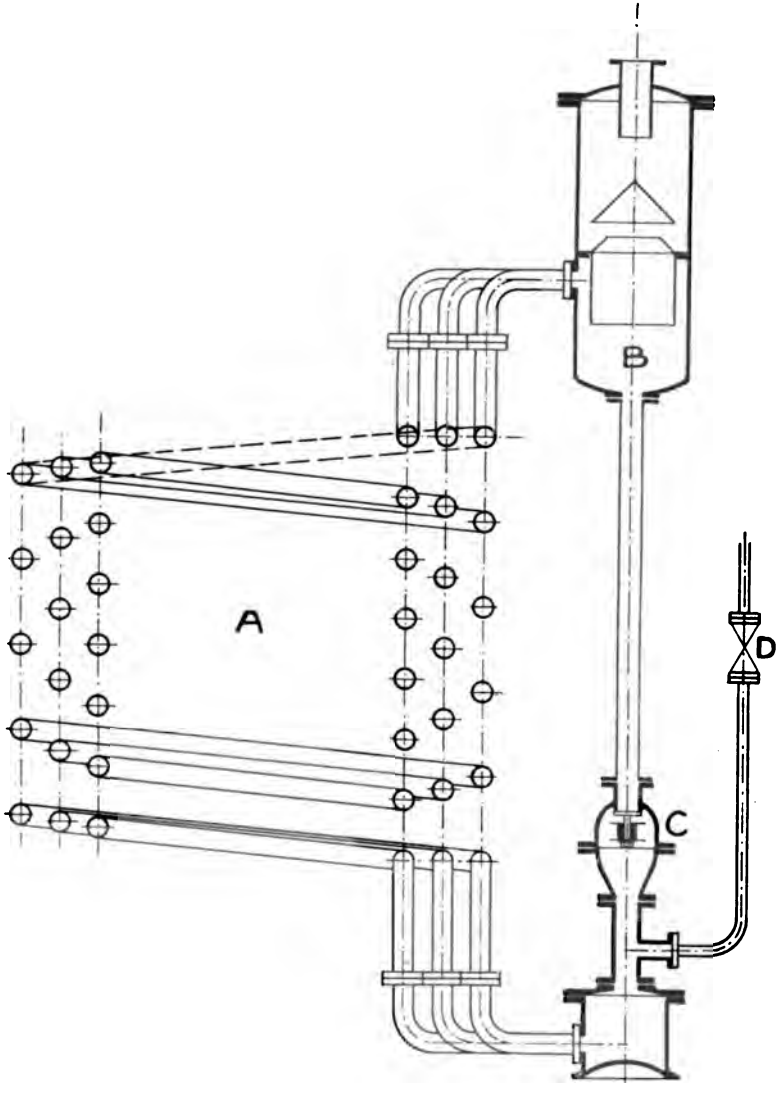


FIGURE 3

tioned systems. The suction and liquid headers are connected by a large vertical tube or so-called accumulator, into which the liquid is fed. The suction is also connected to this accumulator. This system, I understand, also met with a similar fate to the Krebs system, the trouble being a faulty construction of the coil which, according to Stetefeld, did not provide for a continuous upward movement of the refrigerant, causing the coil to become

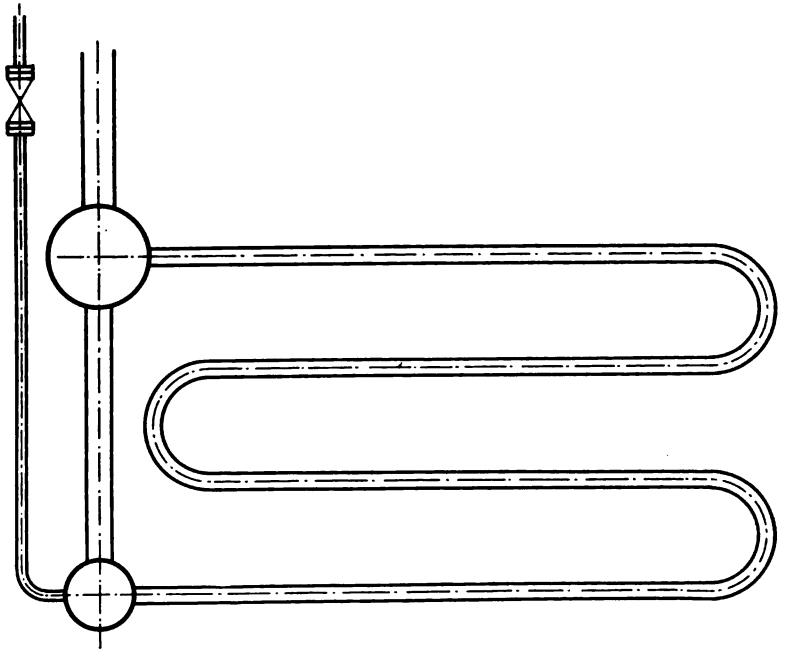


FIGURE 4

gas bound to the extent that the small liquid head would not overcome it.

Besides the two foreign systems mentioned there are quite a number which are more or less flooded systems. One of them is shown in Figure 4. Here we have two wide headers; the liquid enters the lower header and the gas generated by the sensible heat of the liquid escapes through a large connection directly into the suction header. Otherwise the operation is the same as in the other gravity feed systems.

Besides the force feed and gravity feed systems there are several systems that are more or less a combination of the two. The first to be mentioned are the shell type brine coolers, which can easily be operated flooded because they have a large liberating surface; and a separator in the suction line with a liquid return connection added will certainly insure as good a heat transfer as any gravity feed system.

Another system with which I am not very familiar however, is installed to improve direct expansion systems. It consists of a separator which is installed in the main suction line leading to the compressor, but at such a height that the separated liquid can flow by gravity to a coil of sufficient surface to take care of its evaporation. The return of this coil, of course, goes back to the separator. The separator and the coil are on the true gravity feed system with the exception that the refrigerant does not come direct from the liquor line, but comes from over-fed direct expansion coils, the capacity of which had to be increased for some reason without increasing their surface.

An apparatus for the same purpose, but so arranged that the refrigerant is returned to the same refrigerator coil, has been in use in Europe since 1896. A diagram of the arrangement is given in Figure 5. It has been proven to be even more effective than the flooded system patented by Schmitz. A is the regulating valve, B the refrigerator coil, C the separator, D the pump which returns the unevaporated liquid to the refrigerator coil and E is the suction line to the compressor. The apparatus is also intended to provide superheated gas to the compressor and thus increase the compressor capacity also.

It will be remembered that at the October meeting of the Society in Chicago, Ill., in 1909, in the discussion of Mr. Rassbach's paper, Mr. Block stated that an increase of 30 per cent. was obtained over the ordinary system by circulating the liquid ammonia with a pump connected to the Krebs system at the De La Vergne test plant in 1892. This is practically what is covered by the German patent, and had a centrifugal pump been used the Americans could have claimed the honor or having invented the most efficient feed system. A centrifugal pump would not have created the trouble experienced because its stuffing box can be arranged to hold tight easily.

As a development of the above, an apparatus has been designed which does all this automatically and besides does away with the

pump. Figure 6 illustrates this apparatus. A represents the suction from the refrigerator, B the separator, C suction to the compressor, D connection for unevaporated liquid to regulating apparatus, E equalizing line necessary to allow the returned refrigerant to enter the regulating apparatus. In this apparatus there is a rotating feed cylinder F which has three chambers, each with one hole in the top and bottom; the sections a-b and e-f show the holes in the top and bottom plates between which the cylinder rotates, section c-d shows connection G from the liquid supply valve and H to the refrigerator.

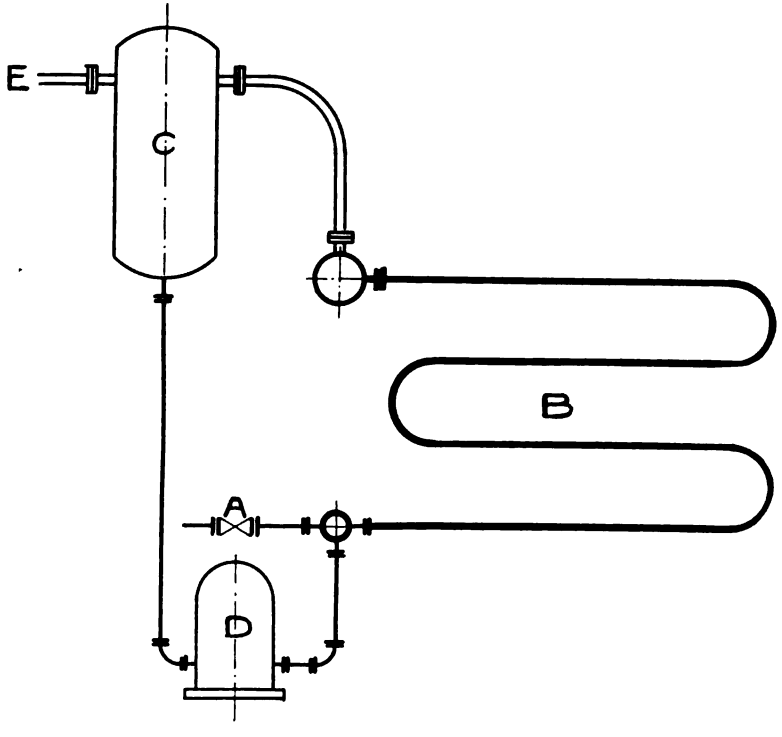


FIGURE 5

The feed cylinder is operated by a gear, and to get an idea of the working of the automatic regulating apparatus, the different phases of operation may be studied for one chamber during one revolution. Starting with the chamber in the position at the left side of the elevation, as shown in Figure 6, it will be observed

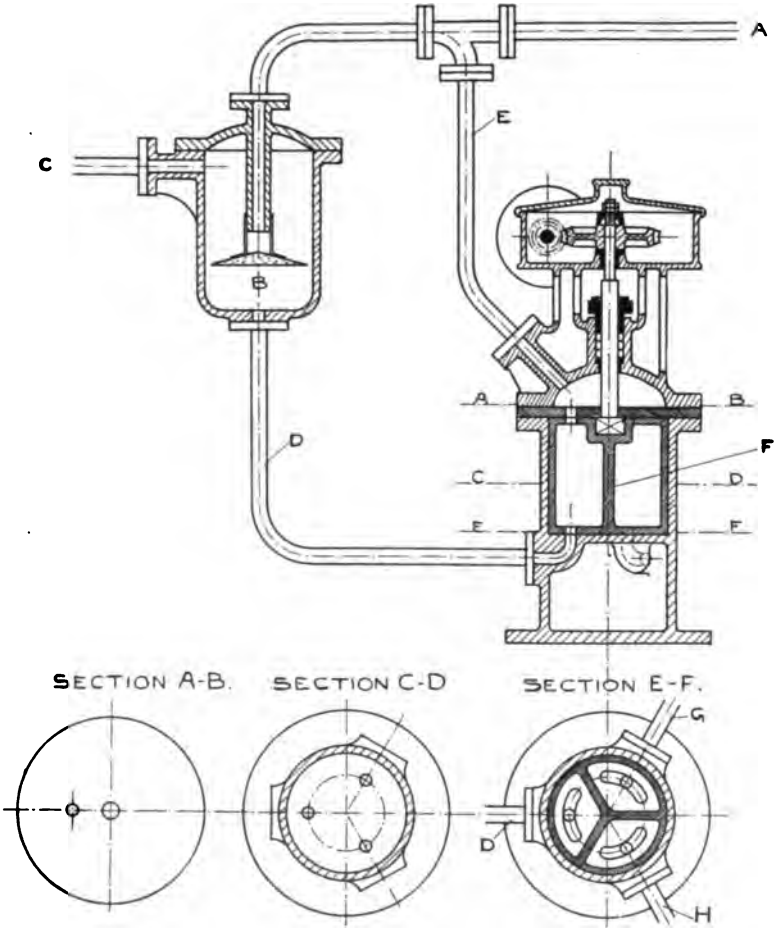


FIGURE 6

that the unevaporated liquid can enter the chamber and fill it with as much liquid as there is present in the separator B, which is equalized with the chamber F through the equalizing pipe E. Assuming that the cylinder rotates in the direction of the arrow, the next opening to be passed is that which registers with the opening from the condenser, and here the high pressure liquid fills out whatever space there is left by the liquid returned from the system. Through communication with this opening the refrigerant in the chamber is brought into connection with the condenser outlet and given the necessary pressure required to make it flow into the chamber below, which it does in passing the third opening, where it registers during the next one-third revolution. Connected to the lower chamber is the liquid supply pipe of the refrigerator coil, into which the refrigerant passes to perform its refrigerating duty, and in which it is partly evaporated. After leaving the refrigerator coil it again passes to the separator B where the gas passes to the compressor, and the unevaporated liquid again passes out through D, beginning another new cycle of operation. The cycle is repeated with sufficient rapidity to properly feed the respective refrigerator coil. The simplicity of the regulation is due to the fact that if so much liquid is returned from the refrigerator coil to completely fill the chamber of the feed cylinder, then there will be no refrigerant added while the chamber is in communication with the opening to the high pressure liquid inlet, but the pressure required to make it flow into the lower chamber is transmitted to it just the same through the condenser connection.

From the foregoing it can be seen that the designer's aim would seem to be to install a feed system which will have the cooling surfaces covered with the liquid refrigerant. But there is another question to take into consideration, and that is the shape of the evaporating surface. As pipes are the most convenient surface. the proposition reduces itself to the selection of the proper diameter of pipe to use, and here the question is: What pipe will give the largest surface for the least amount of liquid refrigerant, if the refrigerant is an expensive one?

In the following tables line 1 gives the internal surface, in square feet, of pipes of various sizes containing one cubic foot; line 2 gives the cross sectional area of the pipes, in square feet, and line 3 the number of lineal feet of the various sizes for the number of square feet of internal surface given in line 1.

	Full Card Weight Pipe						
	½"	¾"	1"	1¼"	1½"	2"	2½"
1	77.3	58.5	45.9	34.8	29.85	23.2	19.6
2	.0021	.0037	.0060	.0104	.0141	.0233	.0332
3	473.8	270.0	167.2	96.26	70.73	42.91	30.34

	Extra Heavy Pipe						
	½"	¾"	1"	1¼"	1½"	2"	2½"
1	88.5	66.3	50.5	37.75	32.1	24.85	20.75
2	.0016	.00295	.0049	.0088	.0122	.0204	.0292
3	623.0	3386	202.8	113.3	82.1	49.05	34.2

From the above tables, line 1, it can be seen that the smaller the pipe the larger is the surface surrounding a given volume, but it has to be further considered that the smaller the pipe the smaller is the opening through which the refrigerant, evaporated by a given surface, can escape. As the pipe size has a great deal to do with the pressure required to circulate a liquid or gas through a coil, one can readily see the importance of this fact.

With the aid of the tables it is possible to select the right pipe size for the refrigerator coil if the heat transfer is taken into consideration, so that, for instance, one would probably select a ½-inch pipe for air cooling in which the coils are very short and large in number, and a 2-inch pipe for a coil in a long ice tank. After considering all this the cost of the refrigerant may be balanced with that of the pipe coil and a final selection made.

From what has been published on the subject of the gravity or flooded system one would infer that there are no further data required for their proper design, but as yet there is no information available which explains the relation between the height of the liquid level above the refrigerating coil and the velocity of the refrigerant in the refrigerator coil. There being so many varied conditions, due to length of coils, diameters of pipe and heat transfers under different conditions, that quite a field is opened here for a careful study and for elaborate tests to improve this part of the feed system.

DISCUSSION

President Neff.—The subject of this paper has been before this Society in the past and it has been thoroughly discussed. You will find a number of papers in our Transactions bearing on this subject. Some of the matter now submitted is valuable as supplemental work to what has been done before.

J. C. Bertsch.—Mr. Baars speaks of a third system of feeding, consisting of coils arranged as in Fig. 2. He says he does not know the reason for the existence of part A and that he would have done away with that. From his succeeding references on which he shows that his system has been used in an ice plant where a second tank was equipped with a similar arrangement, but with a valve for each coil, I infer that Mr. Baars has in mind an installation made by myself in Macon, Ga.

When I had charge of the Macon and Jacksonville plants, consisting of De La Vergne ice tanks with 300-pound cans, with horizontal coils, and a regulating cock for each coil, a time came when we had to increase the capacity. As we had no additional floor space, I proposed to convert these 300-pound tanks into 400-pound tanks. The cans were nearly worn out and had to be replaced anyway, so it was decided to make the change. We increased the depth of the tank by riveting a piece of steel about fourteen inches wide around the top, and made the coils deeper. We had large Vilter compressors beside the De La Vergne compressors. We used to be troubled with a considerable amount of oil which found its way into the old coils. In order to guard against a recurrence of trouble with oil in the coils, and without expending money for a large accumulator, as had been recommended by the late Mr. Rassbach and for which there really was no room, I arranged the pipe connections exactly as shown in Fig. 2, and brought all the horizontal pipes into an eight inch vertical manifold, forming practically an accumulator, with a blow-off cock or drain at the bottom. Without this manifold, to which Mr. Baars attaches no importance, we could not have successfully operated these coils, because the lower pipes would have become clogged with oil. You will now understand the purpose of this manifold; it served also for equalizing the liquid; for example, if there is surplus liquid in any one of the coils, it simply drops down into the manifold and supplies from behind, so to speak, the coil which has not enough. I assure you the system worked perfectly.

Mr. Baars says that in another tank of this type each coil had a regulating valve. This is true, but I have to qualify this statement by saying that the main liquid line supplying these headers had one regulating valve, and that the battery of four tanks was operated by this main valve. The individual regulating valves were left in for the particular purpose of equalizing the temperature in the four tanks, which were side by side. The insulation was poor, but we could not tear it out, so we had to use the tanks as they were. The one on the outside always was short in capacity, while those towards the ice house were doing good work. In order to regulate this, we left the small valves in and shutting off the coils in the middle, thus forcing the liquid to the outer coils. I am sorry Mr. Baars is not here, as I wanted to ask him where he got his reference, but since he is not here I might as well tell you that, judging from the cut, it is my drawing and according to the description it is the plant of which I had charge.

*Ernest S. H. Baars**.—I am pleased to hear from at least one person regarding the result obtained with a feed system with which I am not very familiar. Mr. Bertsch answered my question regarding the part marked A in Fig. 2 indirectly, and by his remarks I note that he also omitted the pipe extending into the manifold, otherwise he would not have operated his tanks flooded as he did.

The construction as shown in Fig. 2 is similar to that used by the Fred W. Wolf Co. The other construction I referred to is that used in can ice tanks by the De La Vergne Machine Co.

**Author's closure under the rules.*

No. 124

DEFINING THE HEAT CONDUCTIVITY OF INSULATORS

By CHARLES H. HERTER, NEW YORK, N. Y.

(Junior Member of the Society)

In this paper the writer calls attention to the fact that the formula generally used for calculating the flow of heat through a wall or insulated surface is incomplete, and that by its application the insulating value of non-conductors is overestimated by 10 to 20 per cent.

This subject was treated quite fully by the writer in articles appearing in *Power,* July 30 and August 13, 1912. It was also taken up by R. L. Shipman of Ithaca, N. Y., in his paper on insulation written for the Third International Congress of Refrigeration, held at Chicago, September, 1913, but owing to Mr. Shipman's absence his paper was not read. I believe it is the intention of our Society to assist its members in their professional work and point out to them errors of practice. Owing to lack of sufficient knowledge or absence of facilities for personal investigation many errors remain uncorrected, but when well established principles of engineering are being ignored to the detriment of our industry, the Society should take notice and decisively declare its position. It is as much our duty to state how the conductivity of insulators should be expressed, as it is the Society's work to formulate standard methods of rating and testing refrigerating machines, to adopt certain physical constants, etc.

It may be stated at the outset that the writer has no pet formula of his own to offer, the formula recommended is one given in various foreign works, also in "Modern Refrigerating Machinery" by Lorenz-Pope and Haven-Dean (1905). A similar formula by Péclet is given in C. P. Pauldings "Transmission of Heat through Cold Storage Insulation" (1905).

NOTATION

H = Total heat passing through wall in B.t.u. per square foot per 24 hours.

S = Surface or area of wall in square feet.

d d_1 d_2 = Thicknesses of the various layers of material comprising the wall, in inches.

r = Coefficient of heat transmission (radiation + convection) at the warm surface of the wall, in B.t.u. per square foot per degree F. difference in temperature between the wall *surface* and the surrounding air.

r_1 = As before, but at the cold surface of the wall.

c c_1 c_2 = Coefficients of internal heat conductivity of the different layers in B.t.u. per square foot per 24 hours per degree F. difference in temperature between the two *faces* of one-inch thick layers.

k = Coefficient of heat transmission in B.t.u. per square foot per degree F. difference in temperature between the air on one side and the air on the opposite side of the wall.

t_1 = Temperature of air on warm side of wall in degrees F. (to be measured one inch from the wall surface).

t_2 = Temperature of the warm surface of the wall in degrees F.

t_3 = Temperature of the cold surface of the wall in degrees F.

t_4 = Temperature of the air at the cold side of the wall in degrees F. (to be measured one inch from the wall surface).

Calculations for heat flow through walls apply, of course, also to ceilings and floors, except that in the case of a basement floor either r or r_1 must be omitted, if there is no air underneath it.

The flow of heat, H, through a single thickness of any material may be expressed as follows:

$$H = \frac{c \times S}{d}(t_2 - t_3), \text{ or, } H = S\left[(t_2 - t_3) \div \frac{d}{c}\right] \qquad (1)$$

Referred to one square foot we have:

$$H = \frac{c}{d}(t_2 - t_3) \qquad (2)$$

With a combination of three different layers, for example, the heat flow per square foot per degree of wall surface temperature difference $(t_2 - t_3)$ equals

$$1 \div \left(\frac{d}{c} + \frac{d_1}{c_1} + \frac{d_2}{c_2}\right) \qquad (3)$$

This is the *only* insulation formula given in Siebel's "Compend of Mechanical Refrigeration & Engineering." It is the proper formula to use for finding the rate of heat flow per degree of wall surface temperature difference. But in actual practice, for example, in cold storage work, the surface temperatures t_2 and t_3 are not known; we know only the air temperatures t_1 and t_4, and then the factors r and r_1 must be allowed for in the formula. The complete formula for a wall of three different layers then becomes:

$$H = 1 \div \left(\frac{1}{r} + \frac{d}{c} + \frac{d_1}{c_1} + \frac{d_2}{c_2} + \frac{1}{r_1} \right) \qquad (4)$$

Fig. 1 illustrates on an exaggerated scale the fall of temperature from the warm air on one side of a wall to the cold air on the

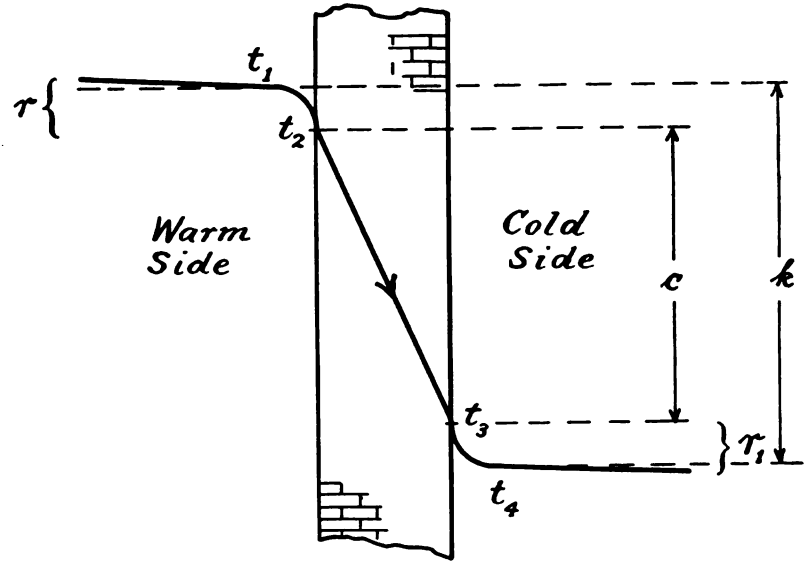


FIGURE 1

opposite side. When the heat flow is constant the warm side receives heat by radiation and convection, the same quantity of heat then travels by conduction through the wall from t_2 to t_3, and is emitted from the cold side of the wall. This condition is represented by the following equation:

$$\frac{c}{d}(t_2 - t_3) = r(t_1 - t_2) = r_1(t_3 - t_4) \qquad (5)$$

Heat conducted = Heat absorbed = Heat emitted

It is well known that the coefficient of heat transfer from heating or cooling surfaces to air, which coefficient is usually denoted by k, but here designated by r, is not constant, but varies with the nature of the surface, with the temperature difference, and especially with the velocity at which air passes over the surface. A number of curves are available showing that the heat transfer in heating and cooling air varies from 18 to 36 B.t.u. per square foot per 24 hours per degree F. temperature difference, if the air velocity is zero. A curve giving the lowest values of any known to the writer is that shown in Fig. 2, which is based on a table given in Kent's "Mechanical Engineer's Pocket Book." The values on this curve are stated to apply to pipes used in indirect hot water heating systems.

As a further guide in the selection of an r or r_1 reference may be had to the following coefficients of radiation by Nusselt, given in B.t.u. per square foot per 24 hours per degree F. temperature difference:

TABLE I. COEFFICIENTS OF RADIATION

Wrought iron, tooled	7.86	B.t.u.
Wrought iron, rusty	21.12 — 22.11	"
Wrought iron, black	21.12	"
Glass	21.62	"
Absolutely black bodies	22.66	"
The following additional values are from Péclet's treatise:		
Charcoal, powdered	16.31	B.t.u.
Sawdust	17.35	"
Plaster, and wood	17.71	"
Sand, fine	17.79	"
Building stone, and canvas	17.93	"
Oil paint, paper, silk	18.22	"
Water	26.1	"
Oil	35.6	"
Lampblack, soot	19.7	"
Lampblack (by Wamsler, recent)	21.81	"

The following values, according to Rietschel, represent the influence of convection in B.t.u. per 24 hours per degree F. difference:

TABLE 2. COEFFICIENTS OF CONVECTION

Air at rest, confined	19.7 B.t.u.
Air in slow motion, in contact with windows	24.6 "
Air in quick motion, air outdoors	29.5 "

Péclet, Rosetti and Stefan-Boltzmann have proposed formulas for determining more accurately the radiation and convection, but as these require the selection of the factors just mentioned which must be estimated, and the variation per degree difference is in-

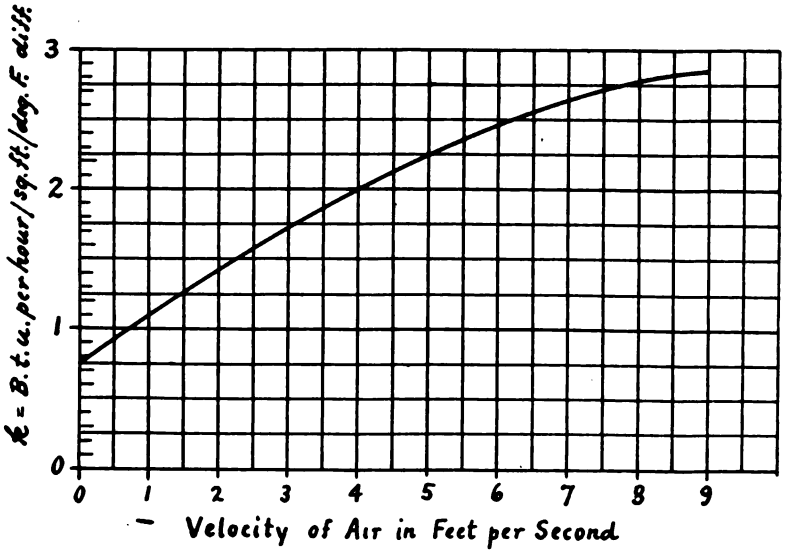


FIGURE 2

significant with the small temperature ranges met with in refrigeration, their long formulas are no help to us. It is vastly better in conducting tests to ascertain the surface temperatures in addition to the air temperatures.

To get the full value of r the radiation and convection should be added. This gives, with confined air, an average value of about 20 + 20 = 40 B.t.u. per square foot per 24 hours. The higher this value of r the lower becomes the conductivity c of any sample un-

der test. This heat exchange at the surface implies, of course, a temperature drop between surface and air, for without temperature difference there can be no flow of heat. The drop is seldom more than a few degrees, but its neglect may affect our calculations 20 per cent. or more as will be shown now by the examination of a few tests appearing in catalogs of manufacturers of insulating materials.

TEST NO. I

In one case a box was constructed of 2-inch thick insulating boards of a brand known as "Union" corkboard. This cork is conglomerated with odorless asphalt, not baked. The box measured outside about 3x3x3 feet. Ice was melted inside of the box. Mercury thermometers indicated the average temperature of the air (not of the surfaces) inside and outside of the box. Temperature t_1 was 70° F., t_4 was 44° F.; difference, 26 degrees. The total heat transmission H per square foot of mean surface of exterior and interior of the box, calculated from the weight of the ice melted (latent heat 144 B.t.u. per pound) and the outlet temperature of the waste water, was found to be 88.66 B.t.u. per 24 hours, which ÷ 26 deg. F. air temperature difference = 3.41 B.t.u., through material 2 inches thick. To obtain the heat transmission per unit thickness, one inch, the customary rule was applied that the heat conductivity varies inversely as the thickness, and therefore the coefficient of heat transmission was made equal to

$$3.41 \times \frac{2''}{1''} = 6.82 \text{ B.t.u.}$$

It will now be realized that the value arrived at represents k and not c. To find c, which is necessarily greater than k, and assuming r and r_1 each equal to 30 B.t.u., we figure that $t_1 - t_2 = (88.66 \div 30) = 2.955$ deg. $t_3 - t_4$ also $= 2.955$ deg. Hence, $t_2 - t_3 = (70° - 44°) - (2 \times 2.955) = 20.09$ deg., and $88.66 \div 20.09 = 4.41$, giving $c = 4.41 \times \frac{2''}{1''} = 8.82$ B.t.u. per square foot one inch thick per 24 hours per degree F. surface (not air) temperature difference. In this case c, 8.82, is to k, 6.82, as 1.292 is to 1. In other words by basing heat loss calculations on the value given in catalog, namely, 6.82, the heat transmission might

be underestimated nearly 30 per cent. Adopting a higher value, 42 B.t.u. for r and r_1, c still becomes 8.14 B.t.u., or nearly 20 per cent. more than 6.82.

TEST NO. 2

In the same catalog a test on the same material is reported by another experimenter, Prof. G. F. Gebhardt, Chicago, who used a different method of testing. He also calls attention to the temperature difference existing between wall surface and air, which difference he eliminates from his tests and calculations.

In this test a value was found for Union corkboard (2—3/32 in. thick) of $c = 1.0178 \times 24 = 24.427$ B.t.u. per 24 hours per inch thickness, per degree F. surface temperature difference. This means a heat loss three times greater than in Test 1. The method of testing, which is stated to have been developed by G. T. Voorhees, includes an ice cooled vessel on top of the specimen, and a vessel underneath, kept at a temperature of about 210° F. by circulating hot water. "By means of a suitable diaphragm the velocity of the water is increased so as to effect a good scrubbing action on the plate." In view of the great disparity in the values of the tests 1 and 2 it is pointed out that the results obtained by Gebhardt on different kinds of insulating boards are merely comparative, and that the lower value only, 6.82 B.t.u., should be used in calculations. It is doubtful whether even "the comparative results may be used with confidence," because they indicate for Union corkboard 2.6 per cent. greater conductivity than for waterproofed lith, while Mr. Starr's ice box tests in the same catalog show the difference to be 14.4 per cent.

CORRECTION FOR HIGH TESTING TEMPERATURE

The mere fact of the high temperature range employed by Gebhardt, namely, 210-32 or 178 degrees F., as against 20 degrees in Test 1, would not prevent us from using his results, because this can be corrected for by Nusselt's formula, who found the internal heat conductivity of insulators to vary approximately with the mean absolute temperature.

In Test 1 this was $\frac{70 + 44}{2} + 460 = 517°$ F.,

in Test 2 it was $\frac{210 + 32}{2} + 460 = 601°$ F.

At the temperature level of Test 1 the conductivity c would therefore be

$$24.427 \times \frac{517^\circ}{601^\circ} = 20.83 \text{ B.t.u.}$$

This corrected result for c is still 2.36 times as great as the probable value, 8.82 B.t.u. No theories have been offered to explain the discrepancy, but in the writer's opinion the high rate of heat transfer is entirely due to the rapid circulation of the hot water across the testing surface. In all technical applications does the heat transmitting capacity of a surface, per degree of difference, increase with the velocity of the fluid, though not in direct proportion. It is a fact that with induced gravity circulation of hot or cold water in the testing apparatus coefficients c are found consistent with the low values obtained in ice box tests.

The variations in results which appear to always obtain in the application of the "ice box method" of testing, also the desire of experimenters to secure figures consistent with prevailing ideas, make it difficult to derive the correct value of c from the reports of tests published.

TEST NO. 3

The following figures based on the original test report and published in the abstract in a catalog on "Rock Cork" serve to emphasize the meaning of the above. In these tests a modified ice box method was used with one vertical effective surface of two square feet. No air agitation was resorted to.

TABLE 3. HEAT TRANSMISSION OF "ROCK CORK"

Number of 1-inch thick layers		one	two	three
Average heat transmission (corrected) in B.t.u. per sq. ft. per 24 hours per deg. F. air temp. difference,	H =	5.70	3.375	2.56
Do., per inch thickness,	k =	5.70	6.75	7.68
Calculated internal conductivity, per inch thickness,	c =	8.14	8.14	8.14
Calculated values for r and r_1		38	39.6	91.4

In the case of the three one-inch thick layers the value of r, 91.4 B.t.u., seems rather high, indicating per Fig. 2, an air velocity ex-

ceeding 10 feet per second, and as this could not have obtained, c must have been 8.75 if k did not exceed 42. Thus:

$$H = 1 \div \left(\frac{1}{42} + \frac{3 \times 1''}{8.75} + \frac{1}{42} \right) = 2.56 \text{ B.t.u.}$$

The manufacturer, Mr. C. C. Hall, being convinced of the accuracy of these tests (made at Purdue University, Lafayette, Ind., in 1908), in referring to the above values for H, declares in his catalog, that "contrary to the generally accepted theory he does not believe the resistance of insulation to be in proportion to its thickness," and since these tests show the conductivity k, per inch thickness, to increase as the insulation is made thicker, he naturally concludes that "no advantage obtains by using solid insulation over 6 inches thick, commensurate with the expense of the additional thickness." In the light of our previous reasoning his conclusions are incorrect, and the three tests are not consistent enough to serve as a fundamental basis for calculations.

FACTOR r A VARIABLE QUANTITY

From the various reports of tests published the present writer has been unable to find satisfactory agreement in the values for r or r_1. Whether the fault lies with the formula or with the tests is not clear. For example, tests have been made in 1910 by Prof. F. L. Pryor, Hoboken, N. J., on impregnated "Star" corkboard 2 and 4 inches thick, and curiously enough, when c is assumed constant r is much less with 4-inch than with 2-inch thick cork. Or, if the full value for r is retained, c becomes less. While with 2-inch thick corkboard r becomes greater on the fan side, owing to wind, with 4-inch thick corkboard no such result is apparent. The difference in the value of c between the 2-inch and the 4-inch corkboard tested, 8.14 and 7.55, respectively, might, of course, be due to some difference in manufacture, but that is unlikely. In the tests enumerated below, the test boxes were kept in a refrigerated room. Incandescent lamps inside the boxes furnished a source of electrical heat. In addition, a fan was used inside the boxes in tests 2 and 8. Each of the four tests shown here represents the second half of a 24-hour run. The mean value of the coefficient k of ten 12-hour tests was found to be 7.007 B.t.u. per square foot per 24 hours per inch thickness; minimum (test 3, still) 6.854, maximum (test 1, agitated) 7.236 B.t.u.

TABLE 4. HEAT TRANSMISSION TESTS OF "STAR" CORKBOARD, 1910

Thickness of corkboard	2 inches		4 inches	
Mean area of test box, sq. ft.	45.2		48.6	
Test No.	2	4	8	10
Air in box, agitated or still	agit.	still	agit.	still
Incandescent lamps, watt hours	878	1284	522	715
Agitating fan, watt hours	443	—	230	—
Total B.t.u. per 24 hours*	9014	8762	5131	4879
Av. air temp. inside of box, °F.	86.6	87.4	91.6	88.6
Av. air tem. outside of box, °F.	30.8	30.9	30.9	30.8
Av. air temp. difference °F.	55.8	56.5	60.7	57.8
Total B.t.u. per sq. ft. per 24 hours.....	199.35	193.9	105.59	100.39
Do. per deg. air temp. diff. $(t_1 - t_4)$ B.t.u.	3.572	3.43	1.74	1.738

*One watt hour equals 3.412 B. t. u. per hour.

The denominators in the following formulas are the calculated values for r, c and r_1:

$$\text{In test 2, } k = 1 \div \left(\frac{1}{43.5} + \frac{2''}{8.14} + \frac{1}{89.3} \right) = 7.144 \text{ B.t.u.}$$

$$\text{In test 4, } k = 1 \div \left(\frac{1}{43.6} + \frac{2''}{8.14} + \frac{1}{43.6} \right) = 6.86 \text{ B.t.u.}$$

$$\text{In test 8, } k = 1 \div \left(\frac{1}{24.04} + \frac{4''}{8.14} + \frac{1}{24.04} \right) = 6.96 \text{ B.t.u.}$$

$$\text{In test 10, } k = 1 \div \left(\frac{1}{23.73} + \frac{4''}{8.14} + \frac{1}{23.73} \right) = 6.952 \text{ B.t.u.}$$

If r and r_1 are increased to normal, c becomes 7.55 B.t.u. (per inch thickness) in the case of tests 8 and 10. Thus:

$$k = 1 \div \left(\frac{1}{43.5} + \frac{4''}{7.55} + \frac{1}{43.5} \right) = 6.952 \text{ B.t.u.}$$

According to this table c must have a value of 7.55 to 8.14 B.t.u., which is 8 to 16 per cent. greater than 7. B.t.u., the value the expert and the manufacturer would have us insert in the formula The mean temperature of the corkboard walls in the above tests was not more than one degree above or below 60° F., which temperature variation is too small to exert any influence upon the value of c.

TEST NO. 4

At the Second International Congress of Refrigeration, held in Vienna, a paper by W. M. Whitten, of Pittsburgh, Pa., was read describing a number of tests on "Nonpareil" corkboard. The final results, giving the amount of heat in "B.t.u. transmitted through one square foot of material one inch thick, in 24 hours, when there is one degree F. difference between the two *surfaces*," were as follows:

TABLE 5. HEAT TRANSMISSION OF "NONPAREIL" CORKBOARD, 1910

Method used:	k or c
Cold-air box, ice in bunker	6.0 B.t.u.
Ice-box, ice in covered metal tank	6.1 "
Oil-box, oil heated in metal tank	6.4 "
Flat plate, electric heat	6.7 "
Hot-air box, heater and fan inside	6.9 "
Average	6.42 "

These results show a total variation of 15 per cent., which is too much. In the paper cited, Prof. Chas. L. Norton, of Boston, Mass., who made the tests, is quoted as stating that "the cold-air and the hot-air box methods may well be adopted for tests of this sort of insulation."

While the values for the rate of heat transmission are declared to be based on "surface" temperature difference, in the cold-air box test at least readings were taken only of the air temperature in and outside of the test box. Hence in that instance at least the value given, 6.0 B.t.u., represents k and not c. In fact, as usual, no distinction between these two coefficients is made, in spite of the fact that in the hot-air box tests temperatures inside and out were taken both with air thermometers, and thermocouples imbedded in the surface. Even moderately accurate testing should have proved the existence of 0.5 to 2 degrees F. temperature difference between surface and surrounding air. In the absence of details we can only surmise that in the case of the cold-air box tests the conditions must have been about as follows:

With corkboard 2 inches thick,

$$k = 1 \div \left(\frac{1}{22.87} + \frac{2''}{8.14} + \frac{1}{22.87} \right) = \frac{1}{0.333} = 3 \text{ B.t.u.}$$

For material one inch thick, k has been simply assumed to be $3 \times \frac{2}{1} = 6$ B.t.u., although, unlike c, k does not vary inversely as the thickness. For one-inch material k might be equal to

$$k = 1 \div \left(\frac{1}{22.87} + \frac{1''}{8.14} + \frac{1}{22.87} \right) = \frac{1}{0.2104} = 4.75 \text{ B.t.u.}$$

or, it might be

$$k = 1 \div \left(\frac{1}{45.6} + \frac{1''}{8.14} + \frac{1}{45.6} \right) = \frac{1}{0.1667} = 6 \text{ B.t.u.}$$

It all depends what values were obtained for r and r_1, in other words, what the average temperature drop was between the cork surfaces and the air.

TESTS 5. AIR AGITATION

In order to show the influence of air agitation, which is frequently used in conductivity tests, we may contrast, for example, the results obtained by both methods when testing water-proof lith board.

This material was tested by John Starr, in March and April, 1911, by the ice-box method. On March 29 an average result was obtained of 2.99 B.t.u. per 2-inch thickness. The average air temperature outside the box was 74.28° F.; inside, 44.07°; difference, 30.21 deg. The heat transmission H per 24 hours per square foot through 2-inch thickness was $30.21 \times 2.99 = 90.33$ B.t.u. Assuming r and r_1 each equal to 40 B.t.u.,

$t_1 - t_2$ and $t_3 - t_4$ each will be $\frac{90.33}{40} = 2.25$ degrees,

leaving $t_2 - t_3$ equal to $30.21 - (2.25 + 2.25) = 25.71$ degrees.

The conductivity is therefore

$c = \frac{90.33}{25.71} = 3.513$ B.t.u. per degree of surface temperature difference, per 2-inch thickness, or, 7.026 B.t.u. per inch thickness.

This value is 12.5 per cent. greater than 5.98, the figure given in the catalog.

If we now maintain the same surface temperatures, but move the air inside of the box with a velocity of 8 feet per second, which according to Fig. 2 would make r = 67 B.t.u. per 24 hours, while the air outside of the box would be moved at a velocity of 5 feet per second, giving r_1 equal to 54 B.t.u., then the temperature drop at the inside

$$t_3 - t_4 = \frac{90.33}{67} = 1.35 \text{ degrees, and}$$

$$t_1 - t_2 = \frac{90.33}{54} = 1.67 \text{ degrees.}$$

The air temperature difference will be

$t_1 - t_4 = 25.71 + 1.35 + 1.67 = 28.73$ degrees,
giving a value for k equal to

$$\frac{90.33}{28.73} = 3.14 \text{ B.t.u. per deg. air temperature difference, which is}$$

5 per cent. more than 2.99 B.t.u., the result obtained with still air. Walter Kennedy, Pittsburgh, Pa., tested waterproofed lith in April, 1909, using a fan inside and outside of the test box, and obtained k = 4.2 B.t.u. per 2-inch thickness.

The samples of waterproofed lith tested by Starr two years later either were of different manufacture, or, what is more probable, the temperature gradient inside of the material becomes steeper when heat is rapidly removed from the surface. (See Fig. 3.)

It is remarkable that the temperature drop at the surface has until now been overlooked by the majority of engineers. Only at the recent Third International Congress of Refrigeration, held at Chicago, Prof. J. A. Moyer presented a "Preliminary Report on the Thermal Testing Plant of the Pennsylvania State College," from which it may be seen that considerable variations of the air temperature near the surface under test have been observed, and yet the conductivities obtained apparently are based on air temperature differences instead of on surface temperature differences.

It should be evident from the foregoing, that in testing various thicknesses of material a different value for k must be expected from, say, 3-inch board than from 2 or 1-inch board, because the in-

fluence of factors r and r_1 becomes of less importance as the thickness of the insulator is increased. Proof of this is found in the tests on "Rock Cork" (Table 3), also in Prof. Pryor's tests (Table 4) where k, per inch thickness, is 6.86 B.t.u. with 2-inch "Star" corkboard, against 6.952 with 4-inch. It is possible that the difference actually was even greater than these figures indicate.

EFFECT OF AIR VELOCITY AND HUMIDITY

Prof. Moyer's report at Chicago, and which appears in *Power* for Nov. 11, 1913, contains the following figures indicating the effect on the heat transmission with change of air velocity and humidity. The air velocity inside of the corkboard cube was in all cases approximately 200 feet per minute.

TABLE 6. VARIATION OF HEAT TRANSMISSION WITH AIR VELOCITY (MOYER)

Air Velocity outside of box, feet per min.	B.t.u. per sq. ft. per degree F. difference per hour
222	0.130
298	0.133
437	0.137
800	0.159
898	0.169
900	0.170
905	0.170

TABLE 7. VARIATION OF HEAT TRANSMISSION WITH HUMIDITY (MOYER)

Air velocity outside of box, 900 feet per min.

Relative Humidity in Per Cent.	B.t.u. per sq. ft. per degree F. difference per hour
70	0.170
76	0.171
84	0.173
90	0.174

ACTUAL TEMPERATURE GRADIENTS

Prof. Moyer also gives the actual thermometer readings taken when testing a cubical box of about 150 square feet exterior surface, the box built of 3-inch corkboard of a brand not specified.

TABLE 8. VARIATION OF HEAT TRANSMISSION THROUGH 3-INCH CORKBOARD (MOYER)

Air velocity inside of box, 200 feet per min.

Location of Thermometers	Air Velocity outside of Box, 600 ft. per min.		Practically Still Air Outside of Box	
	Reading of Thermo.	Temp. Diff.	Reading of Thermo.	Temp. Diff.
1. Air inside of box* °F.	117.5		117.8	
2. Air 1 inch from inside surface	116.5	1.0	117.0	0.8
3. Inside surface of corkboard	113.5	3.0	114.0	3.0
4. Temp. in corkboard 1 in. from inside surface	86.5	27.0	94.0	20.0
5. Temp. of corkboard 1 in. from outside surface	57.0	29.5	66.5	27.5
6. Outside surface of corkboard	48.0	9.0	51.5	15.0
7. Air 1 inch from outside surface	47.5	0.5	47.5	4.0
8. Air outside of box*	46.5	1.0	46.5	1.0

*Thermometer located 2 feet from corkboard wall.

To illustrate graphically the temperature gradients through the 3-inch corkboard as stated in Table 8, I have drawn Fig. 3 in which the solid line, curve A, represents the condition obtained by Prof. Moyer when the air inside of the test box is moved with a velocity of about 200 feet per minute, while the air outside is moved with a velocity of 600 feet per minute. The dotted line, curve B, is obtained with 200 feet velocity inside and practically still air outside.

These temperature gradients presumably were obtained while the flow of heat through the wall was constant for some hours. In that event a number of interesting points may be gleaned from this diagram, Fig. 3.

For example, the curves show that with still air outside of the box there was a temperature drop, between outer surface and a point one inch away from it, of 4 degrees, while inside of the box, where the air velocity was always 200 feet per minute, the difference was 3 degrees, diminishing to 0.5 degree outside of the box when the air was moved with 600 feet velocity. In practice corkboard, unprotected, is seldom if ever exposed to such conditions. It therefore seems more desirable to know the conductivity when the air

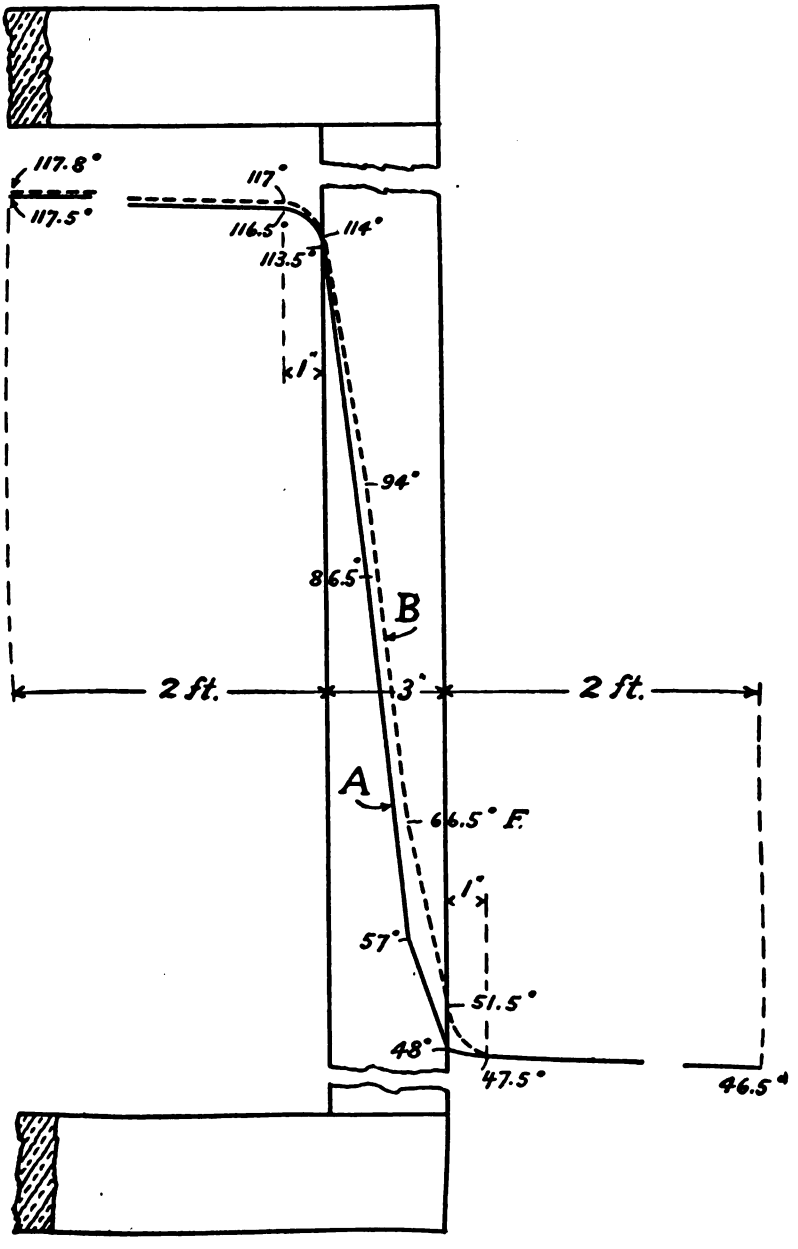

117.8°
117.5°
117°
116.5°
114°
113.5°
1"
94°
86.5°
B
2 ft.
3"
2 ft.
A
66.5° F.
1"
57°
51.5°
48°
47.5°
46.5°

FIGURE 3

is still on both sides of the board; and best of all it is to know the conductivity from surface to surface.

From a temperature gradient alone it is not possible to figure the rate of heat transmission. If the values in Table 6 are plotted, it is found that at zero velocity outside of the box and 200 feet per minute velocity inside of the box, k becomes $0.124 \times 24 = 2.976$ B.t.u. per 24 hours. Whether this value applies to corkboard 3 inches thick or less is not clearly stated. Assuming it to apply to the 3-inch corkboard of Table 8, and Fig. 3, the following calculation can be made in conformity with curve B:

$H = 2.976 \times 69.5$ deg. (air temp. diff.) $= 206.832$ B.t.u. This, divided by 62.5, the surface temp. diff., gives 3.3093 B.t.u. for 3-inch thickness, equivalent to 9.928 B.t.u. per 1-inch thickness. This last value represents c.

$$\text{The value of } r = \frac{206.832}{(117°-114°)} = 68.994 \text{ B.t.u.}$$

$$\text{The value of } r_1 = \frac{206.832}{(51.5-47.5)} = 51.708 \text{ B.t.u.}$$

We can now write the following equation:

$$k = 1 \div \left(\frac{1}{68.944} + \frac{3''}{9.928} + \frac{1}{51.708} \right) = \frac{1}{0.336} = 2.976 \text{ B.t.u.}$$

This is for 3-inch thickness. For 1-inch thickness it would be 3 times more, or 8.928 B.t.u., while the correct value for the conductivity c per inch thickness is 9.928 B.t.u., or 11.2 per cent. greater.

In a treatise entitled "Nonpareil Corkboard Insulation," first issued in 1909, tests made in 1907 are quoted on 2-inch thick Nonpareil corkboard, giving k equal to about 6 B.t.u. per inch thickness, against 6.6 B.t.u. in the case of 3-inch corkboard.

The thicker the material tested the nearer will k approach the value of c, which is the only value that can interest the well-informed purchaser.

CALCULATING A TEMPERATURE CURVE

In order to show how the temperature gradient through a wall composed of various layers may be obtained, the following example is worked out for a 13-inch brick wall insulated with one layer of 3-inch corkboard erected as usual, in Portland cement mortar

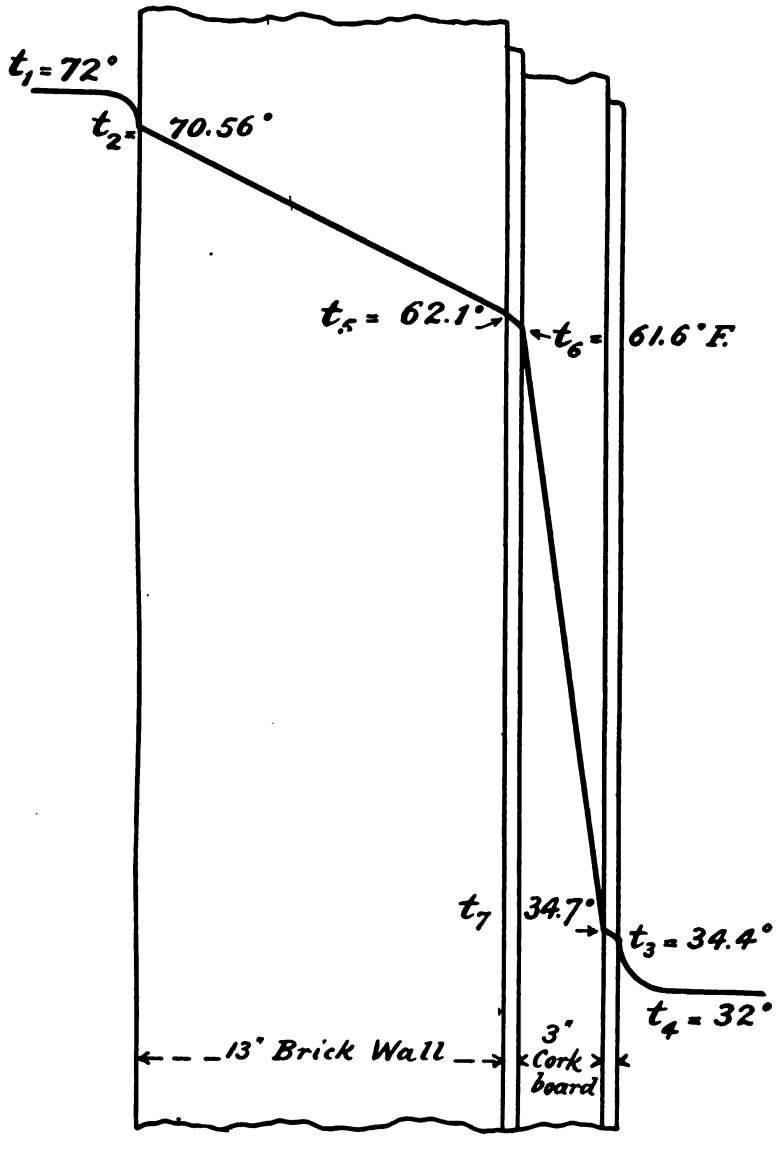

$t_1 = 72°$
$t_2 =$ 70.56°
$t_5 =$ 62.1°
$t_6 =$ 61.6° F.
t_7 34.7°
$t_3 =$ 34.4°
$t_4 =$ 32°
13" Brick Wall
3" Cork board

FIGURE 4

half an inch thick, and finished on the surface in two coats of Portland cement plaster, each coat about one-quarter of an inch thick, Fig. 4.

The thicknesses and (internal) conductivies c, appear in the following formula;

The heat transmission per degree F. surface temp. diff. =

$$1 \div \left(\frac{13''}{110} + \frac{0.5''}{80} + \frac{3''}{8} + \frac{0.5''}{100}\right) = \frac{1}{0.504432} = 1.98243 \text{ B.t.u.}$$

Assuming r = 50 B.t.u., and r_1 = 30 B.t.u., then

$$1 \div \left(\frac{1}{50} + \frac{1}{30}\right) = \frac{1}{0.0533}, \text{ which, added to } \frac{1}{0.5044} = \frac{1}{0.5578},$$

giving 1.79287 B.t.u. per degree air temperature difference. Thus, $1.79287 \times (72° - 32°) = 71.7148$ B.t.u. This, divided by 1.98243 gives 36.1435 degrees as the surface temperature difference.

The temperature drop at the outer surface,

$t_1 - t_2 = 71.7148 \div 50 = 1.4343$ degrees,

therefore $t_2 = 72 - 1.4343 = 70.5657°$ F. Continuing,

$$t_5 = 71.7148 \div \frac{110}{13''} = 8.4615 \text{ deg., from } 70.5657 = 62.1042° \text{ F.}$$

$$t_6 = 71.7148 \div \frac{80}{0.5''} = 0.44822 \text{ deg., from } 62.1042 = 61.6559° \text{ F.}$$

$$t_7 = 71.7148 \div \frac{8}{3''} = 26.893 \text{ deg., from } 61.6559 = 34.7629° \text{ F.}$$

$$t_8 = 71.7148 \div \frac{100}{0.5''} = 0.35857 \text{ deg., from } 34.7629 = 34.404° \text{ F.}$$

$t_4 = 71.7148 \div 30 = 2.3905$ deg., from $34.404 = 32.013°$ F.
or practically 32° F. as expected.

In cases like the above it is necessary to figure the intermediate temperatures accurately, otherwise the lowest temperature reached will not correspond with the figure intended. The exact temperatures calculated will in practice be approximated only.

UNITS OF RESISTANCE

For investigations of temperature gradients and other calculations involving the passage of heat, the use of units of heat resistance should appeal to the progressive engineer. Units of heat re-

sistance are simply the reciprocal of the factor c. By their use the fractions in equations such as (3) and (4) are avoided and changed into a simple multiplication. Mr. Shipman has covered this phase of the subject in detail in his paper already cited.

One advantage in the use of coefficients as applied in this paper is that engineers are more familiar with them. For instance, every body recognizes in the figure 6.5 or 7 B.t.u. per 24 hours the rate of heat transmission claimed for one inch of corkboard, while the reciprocals of these numbers, 0.1549 and 0.1429 respectively, have not been impressed on your minds with equal force.

REPORTS ON HEAT TRANSMISSION TESTS TO BE MORE SPECIFIC

The members of this Society are doubtless aware that there are quite a number of factors influencing the insulating value of a non-conductor as obtained in various methods of testing.

It could be shown that the weight per cubic foot has a distinct bearing on the subject. For example, the value of c (not k) for asbestos packed to 23.9 lbs. per cubic foot is 18.48 B.t.u. per inch thickness per square foot per 24 hours. When packed to 43.7 lbs. per cubic foot, c = 38.9 B.t.u.

The mean temperature of the material under test exerts a marked influence. Granulated cork, with grains 1/16 to 1/8 inch, weighing 10 lbs. per cubic foot, has shown a value of c = 6 B.t.u. at 32° F., 7.94 at 122° F., 10.64 at 392° F., while larger granules, 1/8 to 3/16 inch, weighing 5.3 lbs. per cubic foot, gave c = 7.35 B.t.u. at 32° F., 8.13 at 68° F. and 9.675 at 140° F.

To prove the influence of moisture on the conductivity it may be stated that c for normally dry river sand weighing 102.2 lbs. per cubic foot at 68° F. = 187.8 B.t.u. against 54.15 B.t.u. when entirely dry and weighing only 94.72 lbs. per cubic foot. Further experimenting will be necessary to prove the existence of any variation in c per inch thickness with materials of varying thicknesses.

PROPOSED DEFINITIONS

As a result of the foregoing investigations the writer suggests that future reports of conductivity tests by members of this Society contain an accurate statement describing the material by name and composition, giving its specific gravity, giving the actual temperatures t_1, t_2, t_3 and t_4 as far as known, the thickness of sample tested, its area, also the rate of heat flow per square foot per unit of time.

If any coefficient is expressed it should always represent c, the true internal heat conductivity of the material in B.t.u. per square

foot mean surface per inch thickness per 24 hours at a stated mean test temperature, preferably interpolated and referred to 32 deg. F. and based on the temperature difference existing between the two *faces* of one thickness. Coefficients k, involving air temperatures, are to be pronounced as misleading, for they are true only under the conditions of the test and with the full thickness tested. They cannot be reduced to unit thickness.

The extent of air agitation, if any is used, should be mentioned, also length of duration of test or tests, and preferably a description given of the apparatus used.

If a standard definition for the quality and efficiency of insulators is desired, a committee could be appointed to submit such a standard to The American Society of Refrigerating Engineers for consideration and ultimate adoption.

DISCUSSION

President Neff.—Mr. Herter's paper is along the line of a subject in which we all are intensely interested. As I mentioned in my address to you, we hope to get some results from this testing plant of the Pennsylvania State College, and such a paper as this offers suggestions to those members of our organization who, I hope, will have the opportunity of helping direct the work of that institution. The paper is now open for discussion.

J. C. Bertsch.—I think the paper of Mr. Herter is a very good one. As the president mentioned yesterday in his address, it is our duty to help get at the facts, but it occurs to me that the recommendations of Mr. Herter do not fully cover the ground. It does not help us to know how a certain result was obtained, so long as we must let each manufacturer of insulating material tell us the story from his view point.

Years ago, when cork board was a luxury, we were offered all kinds of test results claimed for rock wool, mineral wool and other non-conductors. Each manufacturer claimed the best result yet obtained. The mineral wool dealer issued a table showing that mineral wool was on top, it had no equal. The hair felt people insisted that nothing could beat hair felt, its efficiency was 100 per cent., at least. If one consulted a paper published by a cork manufacturer it was found that the conductivity of cork had been proven by various authorities to be less than that of all other insulators, and so on down the list. And how does this all come about? Because everyone is at liberty to use that method which will give

him the result desired, and we engineers are compelled to waste our time trying to calculate what the results would be on a common basis. Therefore, I believe the first thing we ought to do is to establish a committee, able and willing to work, to propose to this Society a standard method of testing insulating materials. When this Society has adopted a standard method we can demand that each manufacturer's material be tested by the standard method, or be denied the approval of the profession. The fire underwriters are doing so with success. Every material entering into the construction of a fireproof building, or which is used for fire protection, has to pass the Underwriters Laboratories and be subjected to uniform tests. Only when we do that will we learn the true insulating value of corkboard, mineral wool, hair felt, etc. Once we have a standard method, we can go after standard definitions.

As to a standard method, I want to remark that I do not consider the steam pipe method a proper one; cold storage and ice houses are neither surrounded with steam pipes nor hot water pipes, they are placed on the ground surrounded by the outside atmosphere and are being cooled on the inside; therefore the test should conform as closely as possible to actual practice. Mr. Herter states in his paper that the conductivity changes with the intensity of temperature. If this is so, what good is it to know what the results are with a steam or hot water pipe at 210 degrees F? Have you ever seen a cold storage room exposed to a temperature of 210 degrees? The ice box method is objected to by some, but I consider it by far a better method because it gives us actual facts, it gives us something we can weigh and measure.

It is to be hoped that the incoming president and Council will heed what our president said yesterday, and cause this matter to be taken up by this Society and pushed, not laid over from one year to another, but pushed, and that a standard will be adopted informing us and the manufacturer how his material shall be tested and what constants we have to consider as normal, and then only will we know the actual heat conductivity of each and every insulating material we have to use in our constructions.

H. C. Dickinson.—I have been very much interested in the paper that has just been read. It seems to me that it brings out some points which are of importance to us. In the first place, given any thickness, any wall of insulating material, it is evident that there are three factors which concern us, first, the heat conductivity

of the material itself; second, the effective heat transmission by convection of the layers of air next to the material, and, third, the transmission by direct radiation from the surfaces of the material.

In the problem of heat insulation, there are two phases of importance; first, the relative merits of different materials as heat insulators and, secondly, the total transmission of heat through walls composed of various materials, the latter feature being of interest to the designer of cold storage plants, etc. Just here is the point where I think the man whose life is primarily given to experimentation will take issue with the methods of testing that have been employed almost universally for this problem, for this reason, that so far as has come to my attention, every single method which has been employed and upon which results have been based is carried out in such a way as to introduce the three factors mentioned, instead of being designed to confine itself to one factor, and when we have three factors to determine at once, two of which are very indefinite and are of little importance in the general problem, we are not working to best advantage. Any method which will be satisfactory for the study of the insulating properties of materials must be one which will eliminate the other two factors—air conduction and direct radiation. These two should be studied independently, because, in any installation, these two factors depend upon the method of construction and upon the conditions which obtain. The main factor, the conductivity of the material itself, is the only factor which differentiates, for instance corkboard from lith, lith from rock cork, etc. Therefore that factor is the thing which should be specified, and it is perfectly easy, experimentally, to determine the conductivity of such material with considerable accuracy.

The Bureau of Standards has within the last few weeks been able to undertake a little work along this line, and so far our results are not in shape to present, but, nevertheless, it is very evident from the work which we have done that the specific conductivity of such material can be determined easily and with an accuracy of one per cent. or half of one per cent., provided the materials themselves are uniform to that extent. Therefore, I would like to register my suggestion that before a final method is specified by engineers, the matter should be considered as to the feasibility and propriety of suggesting a method which will give the one factor, the thermal conductivity of the material itself, and whatever methods may be neces-

sary for the determination of the heat transmission through the air layers, etc., should be taken up independently of the other.

President Neff.—I want to express our thanks to Mr. Dickinson for making those remarks to us.

F. E. Matthews.—It may be taken as axiomatic that dissatisfaction preceeds progress, I believe that we have had sufficient dissatisfaction regarding the status of knowledge of heat conductivity of insulating materials to warrant more progress in the future than has been made in the past.

We have in the refrigerating industry some 100 manufacturers of refrigerating machines who are devoting their money and time to the development of apparatus for creating cold. We have only about half a dozen companies who are employing their energies in the manufacture of materials to conserve that cold. This may account for the fact that relatively little progress has been made in the technology of insulation.

We are interested, as Mr. Dickinson has pointed out, in knowing the actual heat conductivity of the insulating material itself, but we also must know the heat flow through the whole construction as erected. In the majority of reports published, describing insulation tests, all the conditions influencing the results are not stated, which places us at a serious disadvantage. The tables of heat conductivity, as usually given, include a variety of materials ranging all the way from copper to eiderdown. In nine tenths of these materials refrigerating engineers are not interested. What concerns us most is the efficiency of the insulation after it is installed. This takes into consideration surface resistance, on which point we have very little, if any, authentic information. I agree with Mr. Dickinson that the first thing to do is to get authentic information regarding the conductivity of the various insulating materials themselves, but this information should be supplemented by equally authentic information regarding the total heat conductivity of the insulation as erected in common practice.

As engineers do not care so much what the surface resistance is of corkboard exposed to atmospheres of varying humidity —for very little cork is erected that way. We are concerned, however, with the total heat conductivity through the brick or other walls as insulated with cork and finished with Portlant cement plaster. The methods of construction most commonly used should receive attention first. I believe the time for that is ripe now,

especially since the Bureau of Standards is carrying on research work in this direction, and in addition a number of educational institutions are preparing to undertake experiments which will benefit practicing engineers. The Society as a whole, I think, should try to profit by the good work that is being done, and it should get it into practical shape for the profession.

I think it would be a good thing to have a committee, as suggested by Mr. Herter, appointed by this Society, to co-operate with the Bureau of Standards and educational institutions or laboratories wherever they may be. This committee to work out these problems and to suggest uniform methods to be pursued in making tests. It should also point out the advantages accrueing to the profession if their suggestions are widely adopted.

J. C. Bertsch.—May I ask Mr. Dickinson whether it is proper to give us some information as to the method the Bureau of Standards is pursuing in testing insulating material, without asking secrets? I don't want to ask anything he can't disclose.

H. C. Dickinson.—Our method is no secret at all, but immature. It is simply a trial method to get ourselves in position to do something more complete. The principle is this; we have four heavy copper plates which are ground to a true surface. They are so arranged that they can be opened and closed and the insulating material to be tested can be laid in this space on the two sides. Between these two central plates is wound a very carefully constructed coil of flat resistance wire in such a form that the energy supplied per unit of surface can be accurately determined. On the inner surfaces of these plates are imbedded a number of thermo-couples in such a way that the temperature of the copper plate surfaces can be determined with accurary. The inner pair of plates is made in the form of what we call a guard ring, a groove is cut almost through the plate all the way around, although the heating element extends all the way across; consequently, if there is some loss from this end, the temperature of this portion will be slightly different from the temperature in the center; nevertheless, the amount of heat supplied to it is the same over the whole surface; we therefore measure the difference in temperature between one surface and the other, the total amount of energy which passes between them being the same on the two sides. These temperatures being maintained constant, we get a measure of the conductivity per unit of cross section between the surfaces of the

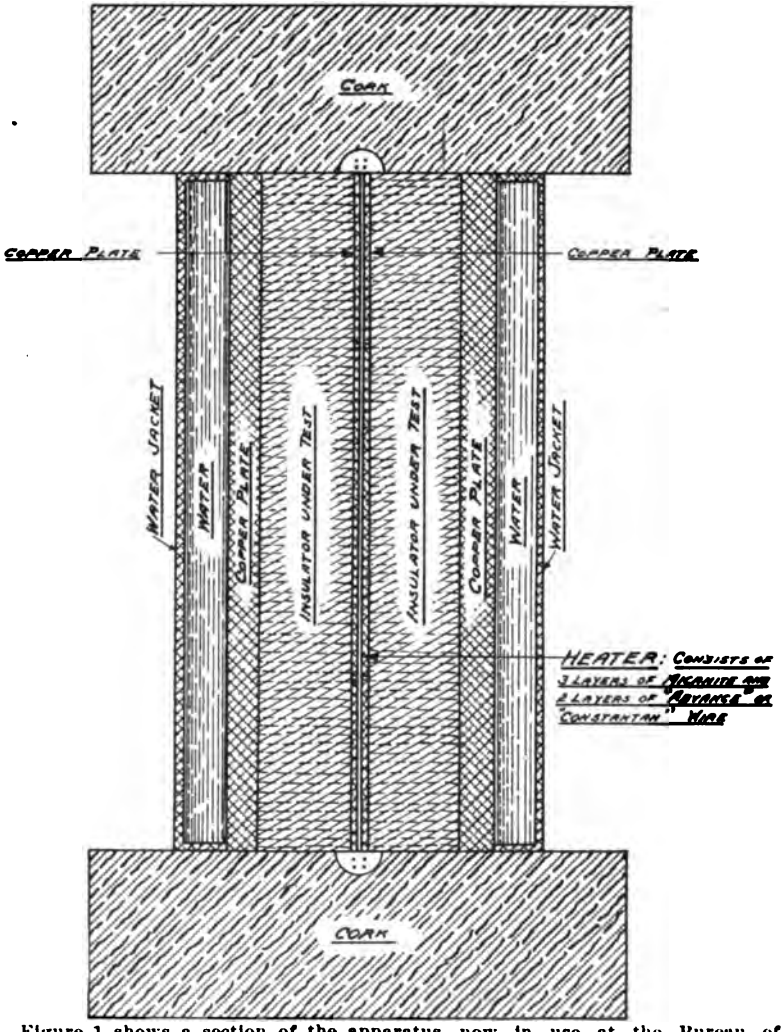


Figure 1 shows a section of the apparatus now in use at the Bureau of Standards, Washington, D. C., for determining the thermal conductivity of insulating materials in sheets not over one inch in thickness.

Beginning at the left of the figure, the parts shown are (1) a water jacket soldered to the back of (2) a copper plate 1 cm thick; (3) a sheet of the material under test, cut 20 cm square (the size of the plates) and held under a known pressure; (4) a copper plate; (5) an electric heating element built up of "advance" resistance ribbon very carefully spaced to give uniformity of distribution, and insulated by thin micanite sheets; (6) a copper plate like (4); (7) a second test sample like (3); (8) a copper plate and (9) a water jacket like (2) and (1).

The plates (4) and (6) are each made of two parts, viz., a central portion 10 cm square and a surrounding rim 10.3cm square inside and 20 cm square outside. The object of this arrangement is to minimize the loss of heat by conduction through the copper plates to the edges, the central square alone being used for the measurements. To further minimize this source of error a small heating coil, shown in section at the edges of the plates, is so arranged as to supply as much heat as is lost from the edges of the heating element, and the whole is surrounded by thick cork insulation.

The surfaces of the copper plates are ground true and their surface temperatures are measured by means of thermo elements (not shown) soldered to them.

two copper plates. We can determine the effect of surface contact by using first a thin layer and then a thick layer or a different number of layers of the same material. We have determined, in this apparatus, not only the conductivity of a number of insulating materials, but we have also started on that problem which has been suggested, viz., the heat transmission through a layer of air.

Charles H. Herter.—I should like to know what you do about the radiation on the end.

H. C. Dickinson.—That part is well insulated, but the slight difference in temperature between this part and the outside is eliminated.

J. C. Bertsch.—With this apparatus you can even test one layer or several layers of paper?

H. C. Dickinson.—Yes, one thing we did was to put in first, one layer of paper, then three layers, then ten, then fifty. The plates in this apparatus are about eight inches square; it is built for thin materials.

Charles H. Herter.—Before describing to you an apparatus I have designed for determining the heat conductivity of insulators, I desire to express my doubts as to the wisdom of declaring any one method of testing as standard. Where accurate results are desired, elaborate apparatus, expensive instruments and long observation are necessary. Such facilities are enjoyed by but few institutions and manufacturers of insulating materials.

The testing apparatus I use is quite simple. With it conductivity tests may be made in an ordinary uninsulated room without necessarily resorting to heating or cooling coils to maintain the room temperature constant. There are two cubical tanks, one above the other, separated by the slab of material under test. Each tank is made of heavy sheet brass and is well insulated on five sides. The lower one is filled with a known weight of hot water and the upper one with cold water. From suitable thermometers the temperature difference between the two waters may be read, recorded, and plotted and the mean difference obtained as a basis for calculating the conductivity. The amount of heat conducted through a sample of known area and thickness is equal to the heat exchanged by the two waters, the specific heat of which is well established, corrected for the amount of heat lost and absorbed through the insulation of the tanks. This has previously been found to be a definite quantity per degree of difference

in temperature between the jackets of the tanks and the air in the room. During a test note must be taken of the water, jacket and room temperatures for 24 to 48 hours and the averages obtained. Since the two uninsulated faces of the brass tanks enclose the sample, the adjacent water thermometers serve also for indicating the average temperature prevailing on each side of the sample.

In this manner and using exact instruments the rate of internal heat conductivity of a sample can be quite accurately determined, because the disturbing factors of radiation and convection are eliminated. To insure that the tanks contain no air pockets provision has been made to compensate for the contraction of the water cooling off, and for the expansion of the water heating up. The exposed testing area of the tanks may be one square foot or larger. Where the testing apparatus is in constant use suitable recording instruments may be employed to great advantage.

*Charles H. Herter**.—The suggestion by Mr. Bertsch to have a committee propose a standard method of testing heat insulators is a very good one, though it may be difficult for the committee to find a method acceptable to all interested. The writer's object in submitting this paper was not so much a desire to see a standard method of testing adopted, as to point out errors in the published results of tests where the internal and external heat conductivities are combined, instead of separated, and to emphasize the necessity for more accurate definitions of the insulation values arrived at by whatever method is used.

In reply to the objection raised to the use of hot water in connection with a testing apparatus for refrigeration insulators it may be said that water is a most desirable medium, because its heat content per pound at any temperature level is more readily obtained than in the case of ice or any other substance. With hot water the temperature difference to which the specimen is exposed may be made large and the accuracy of the test correspondingly increased. While the relation between the internal conductivity and the average test temperature used is not definitely established for more than a few insulators, it is certain that the resistance offered to heat flow diminishes when the mean temperature is reduced, as pointed out in the last part of this paper. In accepting results

*Authors's closure under the rules.

of such tests without corrections for high average temperatures the refrigerating engineer errs only on the conservative side. However, it is possible to estimate with a fair degree of accuracy the gain in insulating value obtained at low temperatures.

It has been suggested that the ideal method of testing conform, as nearly as possible, to actual practice. Since insulators are usually erected in conjunction with structural materials, and are likely to lose its effectiveness owing to present of joints, exposure to moisture, deterioration, etc., a practical test on a large scale would doubtless be very valuable, but also very costly, and can therefore not be proposed for general adoption. With proper manipulation satisfactory results may be obtained with small apparatus in the laboratory, according to Mr. Dickinson, of the Bureau of Standards. It will be noted that Mr. Dickinson agrees with the writer in carefully differentiating between radiated and conducted heat, the latter value being the only one that need interest the purchaser of insulation.

Mr. Matthews lays stress upon the desirability of ascertaining the total heat flow from the air on one side of a wall, as usually insulated, to the air on the other side. If, however, the inner conductivity of the various layers comprising such insulated wall is known, then the total resistance including that on the surfaces may easily be obtained as shown by Fig. 4 and example accompanying same. In actual practice the heat loss at the surfaces plays only a small part in comparison to the heat transmitted through the body of the wall. This is apparent in Fig. 4, where the two surface resistances combined cause a temperature drop of 3.84 degrees F., while the temperature curve through the body of the wall covers 36.16 degrees. For the same reason the influence of humidity of the air on both sides of a wall upon the total heat transmission may as well be omitted from the refrigerating engineer's calculations, because, according to Professor Moyer's figures, Table 8, the effect of humidity does not change the insulating value of corkboard by more than three per cent. In the absence of exact figures the writer prefers to add about 20 per cent. to the theoretical insulating values of structures to allow for the various factors tending to increase the heat loss as ordinarily estimated.

No. 125

Discussion of the Topics—AMMONIA PURIFIERS OR REGENERATORS, AND FOREIGN GASES IN REFRIGERATING SYSTEMS.

Louis S. Morse.—The York Manufacturing Company build purifiers and ammonia regenerators, for which there seems to be an increasing demand by the trade. We build them in different sizes, both vertically and horizontally. On one of our standard ice making systems, which we are now selling, we have a vertical accumulator inside of which is an ammonia liquid coil partly submerged in the brine in the freezing tank. This accumulator serves as an excellent ammonia purifier, as we find that the oil and other impurities will collect in the bottom of this shell, so that they can be readily drawn off when necessary.

F. L. Fairbanks.—Do you have any provision for taking out the gases of decomposition and dissociation, also foreign gases?

Louis S. Morse.—We do that in the regular ammonia purifier by purging.

F. L. Fairbanks.—Then you do not take care of the non-condensible gases?

Louis S. Morse.—No, we dispose of the foreign gases by the old method of purging out into a bucket of water.

F. L. Fairbanks.—We have designed an ammonia purifier for anhydrous ammonia in connection with a shell cooler and condenser system. It works very well. Most of our trouble is with foreign gases of decomposition. In driving our compressors this summer we found that we were exceeding the safe temperatures at which ammonia and oil can apparently be handled, and we think perhaps we have arrived at the point where single stage compression has to stop. The volumes handled are so large that, despite machines in excellent condition, we are running up temperatures of 400 degrees F. and this seems to be the limit. We reached that temperature wth the machine running at about 65 revolutions per minute. Up to about 50 revolutions our temperatures seem to be normal, but after passing 50 to 55 we get an increase in temperature which seems to be cumulative and works up with the speed of the compressor. We have devised two or three minor methods to remedy this condition for the time being,

but we found it was necessary to take care of the gases of decomposition. Therefore, we have provided a still through which we pass the gas for certain condensers, blowing it through the still with a small compressor, until the water has absorbed a certain per cent. of the ammonia, the gas passing through caustic soda which is placed so as to expose a large surface to the gas. By this method we are getting practically pure anhydrous ammonia and excellent results, although, of course, the process is not practical with liquid. We have little or no trouble from the liquid; we separate oil from liquid ammonia very readily in our condensers.

Louis Block.—When you speak of decomposition, do you refer to the ammonia or to the oil?

F. L. Fairbanks.—I mean both, dissociation of the gases of the ammonia and of the oil.

Louis Block.—At that temperature?

F. L. Fairbanks.—Yes, sir.

Hermann Dannenbaum.—I do not believe that ammonia will decompose unless the conditions are abnormal. I do not believe that under normal temperature conditions ammonia will decompose. Whether there could be any formation of non-condensing gases by the mixing of ammonia gas with oil in the compressor, I am not prepared to say, and I do not believe that can be determined except by a series of experiments. I believe a paper was to be read on this subject by a member from St. Louis. He wrote us in regard to it and asked what information we could give him. We replied that whatever opinion we might express would be guess work, and that if he wanted to have any definite information on the subject the Society should perhaps go to one of the colleges equipped with a refrigerating plant and ask them to work this plant with different kinds of oils and under different temperature conditions, etc., and actually analyze non-condensible gases which may accumulate, to see if they are gases of decomposition, or merely air. I believe Mr. Fairbanks just stated, if I understood him correctly, that they were heating their still and absorbing the foreign gases in caustic soda.

F. L. Fairbanks.—You misunderstood me.

Hermann Dannenbaum.—Oh! you mean you use the caustic soda only for drying; that's right. I see in the manner I have suggested the only way for securing definite information on the question whether ammonia and lubricating oil, under high heat, will

form foreign gases, and what these are. I do not believe that ammonia itself would decompose. Mr. Richardson, of Chicago, analyzed, some two years ago, the so-called "foreign gases" in condensers and found them to be air. Apparently he did not find any free nitrogen in excess, or hydrogen, which he would have found in case there was any decomposition of ammonia.

F. L. Fairbanks.—We know that we are getting decomposition of ammonia, we do not guess at it all; we have had analysis made and feel very sure.

John C. Sparks.—May I ask what was the analysis of those gases?

F. L. Fairbanks.—I do not recall exactly; a proportionate amount of nitrogen and free hydrogen, besides the hydro-carbon gases, presumably due to the decomposition of the oil. We know also that with 400 degrees temperature we are beyond the fire and flash test of any ammonia or any oil which has a proper cold test. There is no guess work about that and we are very positive that we are decomposing ammonia. I do not know just what causes the decomposition; it is immaterial, as a practical item, whether it is a combination of the temperature and the oil vapors, or whether it is due entirely to the decomposition of the ammonia at that temperature.

We have the characteristics and are testing it in sufficiently large quantities to show that we are getting it, and it is necessary, as you readily appreciate, that if we do get these foreign gases they must be removed. I might say that our operating instructions are that our condenser and cooler pressures must be within five points of the theoretically possible, and our charts show that to be the case 24 hours a day. Under those instructions you can readily appreciate that the operating force cannot meet those conditions if they have even a slight proportion of foreign gases or air in the system. We get practically no air now, because our rod boxes are sealed with high pressure gas, and we can run our compressors with 25 inches of vacuum, if we wish, without taking in any air through the stuffing boxes. We know these are our conditions, and I simply mention this system as an absolutely positive way of getting rid of these gases without blowing ammonia into the atmosphere or into buckets of water as in the old way.

John C. Sparks.—I agree with Mr. Dannenbaum that at that temperature you get incondensible gases from your oil. When-

ever you heat oil there is always a loss in distillation. Take the method of enriching the illuminating gas in this city; hot gases are passed over oil and a portion of the oil becomes incondensible and will not go down again into the oil. The gases that you get are the products of the incombustible gases from the oil.

F. L. Fairbanks.—Where does your nitrogen and hydrogen come from?

John C. Sparks.—I would like to know. Your temperature never exceeded 400 degrees F.?

F. L. Fairbanks.—Yes, 425, possibly 450. The gases in the compressor cylinder proper may have reached 500 degrees F.

John C. Sparks.—Your nitrogen might have come from the air.

F. L. Fairbanks.—Where does the air come from? We do not have any pressure below atmosphere that we know of, and it is impossible to get atmospheric air into a system kept at a higher pressure.

John C. Sparks.—Mr. Dannenbaum, have you ever heard of ammonia actually dissociating under 600 degrees F.?

Hermann Dannenbaum.—I don't know what could happen to it in a compressor in the presence of ammonia oil. A few years ago White & Melville made experiments under various conditions to determine decomposition of ammonia in connection with by-product cake ovens. They tried to find the temperature to which the gases could be heated without decomposing ammonia, and found that at 800 degrees F. there was practically no decomposition under the conditions they operated. That should prove that ammonia itself does not decompose at the temperature stated. I believe it would be desirable if some definite experiments were made to inform refrigerating engineers what kind of oil should be used under abnormal working temperatures.

John C. Sparks.—After all it is very simple; you can take the ordinary apparatus and use the bromine water test for hydrocarbons and then examine the gas after that.

F. L. Fairbanks.—We have demonstrated that to our satisfaction at least. So far as we know, there is only one kind of oil we can use for ammonia compressors. Of course, it is a mineral oil. We are limited in the qualities of that mineral oil to two things, the cold test and the flash test. We have gone beyond the flash test and up to the fire test. We import an oil from Russia

which is practically a pure mineral oil. In this we get a cold test of 40 degrees below zero F. We are carrying right now possibly 12 to 15 barrels of that oil in each of our coolers, and very often, if we get short of ammonia, we put in six or eight barrels of oil to make up the loss. We do not undertake to separate it at all, except after we have apparently dissociated or decomposed a certain portion of that oil. That takes place after the flash point is reached. Hence you are limited entirely in your oil; you cannot make the oil and there is only one type that can be used whether or not decomposition takes place.

Louis Block.—What is the flash point of that oil?

F. L. Fairbanks.—The flash point of the Russian oil is 320 degrees; the fire test runs about 375 to 380; it is not low; there is no American oil that reaches that point with the cold test we demand. We have a cylinder oil reaching 720, but we are now talking about ammonia oil and not steam cylinder oil. You must have an oil that will remain liquid at the temperature of your coolers.

John C. Sparks.—As a light on the subject, are you familiar with the manufacture of sulphate of ammonia from shale, Dr. Dannenbaum?

Hermann Dannenbaum.—Yes.

John C. Sparks.—I went out to Colorado this summer for the Standard Oil Company on exactly that point. The temperature in those shale retorts in Scotland is about 1,200 degrees F. Where the ammonia is generated, of course the temperature drops immediately. In other types of retorts they run between 600 and 900 degrees and there is very little loss of ammonia.

William H. Bower.—The fact that ammonia is the product of high temperature distillation I think should prove that the conditions in a compressor cylinder would not decompose ammonia; it would be impossible to get a high enough temperature. As Mr. Dannenbaum said, the only way to settle this question is by analyzing the gases, which are not condensible at noted temperature and pressure. My own investigations practically confirm Mr. Richardson's experiments, I find that all we get is air from the condenser system.

President Neff.—This discussion should also point out ways for getting rid of those things if they exist. It is very interesting

to find out what causes them, but, for the time being, we have got to do something to help out.

F. L. Fairbanks.—Is it possible that the friction of the metallic surfaces combined with other local conditions in the compressor is the cause of the trouble? Might not the friction between the packing rings and the surface be responsible for a considerable increase in temperature at that point? Could not the surrounding metal in conjunction with wire drawing of the gas, and similar influences, lead to dissociation, if there is dissociation; and if any experiments are to be made, should they not be made under working conditions, instead of in the laboratory, in order that the experiments be of value to the operating engineer? We are running plants and must keep them going. That the conditions mentioned do occur we know, also that we can meet them, as I stated. Still, it is of value to know where they come from; therefore it seems to me that a paper on this subject prepared by some of the chemists would be of value, if worked out under conditions of actual practice.

John C. Sparks.—I have taken many samples, but never found any hydro-carbon gases.

F. L. Fairbanks.—Where the working temperatures were 400 and 425 degrees?

John C. Sparks—I don't know that they were as high as that.

F. L. Fairbanks.—In the machine I have in mind, we use nine accurate thermometers on the suction and discharge pipes. The readings are entered in the log every hour, but the volumes are so great that moderate errors have no effect. We find that up to a temperature of 340 to 350 degrees we are not bothered seriously; but when our temperatures are over 390, dissociation or decomposition of gases occurs, our head pressure goes up, and that has to be stopped.

John C. Sparks.—I believe the advantage you are gaining on the extra low cold test oil is offset by the amount of incondensible gases you are getting by using a low flash oil.

F. L. Fairbanks.—Can you tell me where there is an American oil with a cold test down to zero and giving a higher flash test than 325 degrees? We have been to the Standard Oil Company and they say they cannot give it to us. I do not mean an advertised zero, but an oil which will remain thoroughly liquid in our rooms kept at 0 degree F.?

John C. Sparks.—I understand they have one or two oils, distributed by Swan & Finch, for instance.

F. L. Fairbanks.—We are dealing with them right along and are using an American oil and a Russian oil. The American oil costs us 20 cents and the Russian oil 40 cents per gallon, so it is quite an object to use the American oil. In our street pipe line we are using the best the Standard Oil Company can give us.

John C. Sparks.—What is the cold test?

F. L. Fairbanks.—It will run from zero to 8 below and has to be selected. We test every barrel. Out of a lot of a dozen, one or two will run 5 or 6 below zero and the rest do not. They say they cannot help it and will not take an order at $5.00 per gallon for oil giving us 20 degrees below zero F. The Russian oil has the wax taken out of it by Nature. Tests in our laboratory show that all American oils we have been able to get with the zero cold test have a flash point between 290 and 310. This Russian oil has been running 320, 325 and in some cases 330. Those are our own tests and have been corroborated by chemists who make that work their specialty.

John C. Sparks.—Wouldn't it pay you to go up on the cold test?

F. L. Fairbanks.—That would help. American oil having a higher cold test has also a lower flash test. With the Russian oil we gain at both ends, that is why we import it and pay the money for it.

R. L. Shipman.—What pressures are you using when you get that temperature of 400 degrees?

F. L. Fairbanks.—It depends altogether on the purity of the system; our condenser temperature governs entirely our discharge pressure. The pressure goes up when we have the foreign gases in the condenser, not before. The temperature is not due to the pressure, but simply to super-heat.

R. L. Shipman.—Your suction pressure runs about what?

F. L. Fairbanks.—Is the low temperature system, kept at 12 to 15 degrees below zero, the suction pressure is abut four pounds, gauge, and on the high temperature or street pipe line system, about 35 pounds, gauge.

R. L. Shipman.—And what is the head pressure?

F. L. Fairbanks.—At the present time, with condensers clean, it runs about 110 to 115 pounds.

R. L. Shipman.—And still you get a discharge temperature around 400 degrees?

F. L. Fairbanks.—We do not now, because the condensers are clean and the machine is running slower, but we can get the 400 degrees temperature at any pressure, provided we have enough foreign gases in the system to prevent condensation at that temperature.

R. L. Shipman.—Foreign gases reduce the effective condensing surface and thus cause an increase in the head pressure. This in turn brings up the temperature. But foreign gases cannot reach the compressor in any considerable quantity if a liquid seal is maintained in the liquid receiver, as should be.

F. L. Fairbanks.—Wouldn't super-heating or wire drawing do it?

R. L. Shipman.—Wire drawing is a cooling process, not a heating process.

F. L. Fairbanks.—On the discharge side?

R. L. Shipman.—Yes, on any side, allowing gas to flow through an orifice is a cooling process, the final temperature is lowered slightly.

F. L. Fairbanks.—But the high temperature can be obtained regardless of the pressure; at least we do obtain it.

R. L. Shipman.—I have had a great deal of experience in observing the discharge temperature. With 10 pounds suction pressure and 200 pounds discharge pressure I never obtained a temperature higher than 320 degrees; with 15 pounds suction pressure and 200 pounds discharge, it runs about 300 degrees; with 15 pounds suction and 185 pounds discharge pressure, it runs about 285 degrees. Increasing the speed of the compressor does not change that, it has a tendency to run the discharge temperature down if you do not increase or change the ratio of the pressures. One thing that does bring up the discharge temperature rapidly is leakage, and if you get a radical change in discharge temperature it must be due to leakage, that is, hot gas slides back from the high pressure side and heats up the gas on the low pressure side. If you are trubled with these abnormal discharge temperatures, would it not be better to compound the compressor?

F. L. Fairbanks.—I have already stated that in my opinion our large compressor represents the limit in single stage compression. I do not know that anyone has ever reached that point,

but we have, undoubtedly. This compressor was designed for a speed of 75 revolutions per minute and we hope to get 90. As far as the compressor is concerned there is no reason why we cannot. It has three 30 x 50 inch cylinders. We have a spare head equipped with a spare set of valves which is made thoroughly tight and put on to a cylinder as soon as there is any leakage. There is some slippage, but it is absolutely impossible to operate any compressor or any set of valves without some slippage; further than that we have reached a thickness of cylinder in which we cannot get sufficient cooling effect, because the transfer of heat is slower than in thinner cylinder walls. Whether a portion of our troubles is due to that, and a portion of them is due to the slippage in so large a machine, we are not prepared to say, but what I mean to state are not technical points or theory, but actual facts as to what we are experiencing, what conditions we have to contend with and provide for.

R. L. Shipman.—One point that has not been brought out yet is the height of the discharge pressure whenever you get 400 degrees temperature.

F. L. Fairbanks.—We have had it 150, 175 and 180; it does not seem to make any difference. The logs show that it varies, particularly with the speed. After we get over 50 to 55 revolutions, the effect, apparently, is cumulative.

R. L. Shipman.—It may be due to slippage, or to reduction in suction pressure caused by restricted suction pipe or valve openings.

F. L. Fairbanks.—We may have some slippage, but it must be less than in our other compressors, which are smaller and run at the same speed without giving us this trouble.

R. L. Shipman.—With 15 pounds suction pressure you should not get a temperature higher than 300 degrees, unless you discharge pressure exceeds 200 pounds.

F. L. Fairbanks.—We should not, but we do.

R. L. Shipman.—You speak of theory; this is not theory, because the tests I have made have been on working compressors, not one of them but several, and I have never seen a compressor in good shape that would give a temperature above 300 degrees without water in the jacket, no matter what is the thickness of the cylinder wall. With water in the jacket the temperature will be less than 300.

F. L. Fairbanks.—We have three cylinders, the thermometers are checked, and in all three cylinders they agree very closely. To me it seems utterly impossible to get three cylinders in which the leakage would go and come together, with fifteen valves in each cylinder.

R. L. Shipman.—In the tests I have mentioned before, we bored holes in the discharge valves and observed the effect on the discharge temperature. You are getting exactly the same result we did. When we bored a one-eighth inch hole through a discharge valve of one cylinder of a 12½ x 18 inch compressor, we noticed an increase in the discharge temperature of forty to fifty degrees.

F. L. Fairbanks.—Was that cumulative?

R. L. Shipman.—No, it would reach a constant temperature and stay there at a given speed of the compressor. With no water in the jacket, this discharge temperature would *decrease* with increase of speed and *increase* with decrease of speed.

F. L. Fairbanks.—But it would come up gradually?

R. L. Shipman.—Yes. Then we bored another one-eighth inch hole in that same discharge valve and it increased the temperature about 80 degrees, so I think from that experience that you must be getting similar results, and that there is slippage through your valves.

Louis Block.—Mr. Fairbanks may have had conditions which we know nothing about and which he, perhaps, does not think of at this moment. I agree with him that speed has something to do with it, because there is no cooling effect; the higher the speed of the compressor, the less is the cooling effect of the compressor, and therefore if his gas comes to the compressor in a slightly superheated condition, it will be materially superheated before the compression begins, and in that case he may get temperatures of 400. Those are single acting compressors?

F. L. Fairbanks.—Yes.

Louis Block.—So it is possible, without any cooling, to have the gas highly superheated during the time of aspiration, and he may get a very high final temperature, even with pressures below 180 pounds.

R. L. Shipman.—There is possibly a misleading statement in my remarks, to the effect that an increase in speed increases the discharge temperature. An increase in speed will not increase the

discharge temperature if you have no cooling effect on the outside. If you are cooling the cylinder with jacket water, as most compressors are operated, then increasing the speed will increase the discharge temperature, but never to a degree higher than it would be if you had no cooling effect, no jacket water; so the maximum temperatures I have given you are correct and there is absolutely no argument against it that I can see.

Louis Block.—We have talked very little about ammonia purifiers?

President Neff.—We tried to get a start on that subject, but discussed disintegration of ammonia and high temperatures.

IN MEMORIAM

	Born	Died
Blethen, Henry,	February 27, 1857	April 24, 1909
Becker, Victor H.,	June 6, 1852	November 15, 1912
Boyer, Francis H.,	September 6, 1845	February 21, 1909
Collins, John Glenn,	July 28, 1854	April 19, 1908
Golden, Albert J.,	November 7, 1872	September 24, 1913
Gould, Ovid M.,	April 23, 1838	February 21, 1911
Haire, David E.,	November 16, 1862	December 1, 1913
Hier, Frank T.,	July 6, 1859	February 2, 1912
Huntley, Clifford E.,	December 14, 1868	November 14, 1912
King, Rockwell,	1853	July 27, 1905
Maschwitz, Carlos,	May 7, 1862	1911
Penney, Edgar,	February 13, 1845	November 14, 1913
Siebert, Alfred	1853	July 20, 1909
Smart, John M.,	August 8, 1866	April 14, 1912
Smith, Edmund J.,	October 21, 1856	September 17, 1906
Tough, L. M.,	1846	April 15, 1911
White, Frank H.,	September 22, 1874	May 26, 1907
Wills, James,	April 30, 1845	March 29, 1910

LIST OF MEMBERS

*ADAMS, T. A., (1912), Manhattan Refrigerating Co., 525 West street, New York, N. Y.

ADAY, F. M., (1911), 79 Milk street, Boston, Mass.

ALLISON, C. E., (1911), Canadian Ice Machine Co., 163 Yonge street, Toronto, Canada.

ARMOUR, NORMAN H., (1911), Calle 49, No. 860, La Plata, Argentine Republic.

ARMSTRONG, C. G., (1911), 149 Broadway, New York, N. Y.

ASHTON, WALTER S., (1907), St. Louis Brewing Association, 703 Wainwright Building, St. Louis, Mo.

*ATWOOD, JOHN C., (1905), National Ammonia Co., 3600 North Broadway, St. Louis, Mo.

AUE, J. E., (1904), 102 Sickels avenue, New Rochelle, N. Y.

§BAARS, ERNST, S. H., (1907), Vilter Manufacturing Co., 872 Clinton street, Milwaukee, Wis.

§BACH, CHARLES G., (1911), 672 Buffum street, Milwaukee, Wis.

BAER, ALVIN H., (1905), Frick Co., Waynesboro, Pa.

BALL, P. D. C., (1904), (Vice-President 1905-'06, Director), 3003 North Broadway, St. Louis, Mo.

BATES, GUY, (1909), 32 Norwood avenue, Summit, N. J.

§BAVIER, ROBERT N., (1909), Ice Manufacturing Co., 1480 Broadway, New York, N. Y.

BECKER, VICTOR H., (1909), Pilsbry-Becker Engineering & Supply Co., 200 North Main street, St. Louis, Mo.

BEHN, CARL, (1904), (Director), Buffalo Refrigerating Machine Co., 126 Liberty street, New York.

§BEIN, F. L., (1913), 4708 West Prospect street, Kansas City, Mo.

§BEIN, G. F., (1909), 1830 Hurley avenue, Fort Worth, Texas.

BERNA, GEORGE, (1904), 140 Giles street, Ithaca, N. Y.

*BERRYMAN, ROBERT J., (1909), Wayne Ice Manufacturing Co., 4165 Wayne avenue, Philadelphia, Pa.

BERTSCH, J. C., (1904), 601 West One Hundred and Fifty-sixth street, New York, N. Y.

*BINZEL, PETER, JR., (1909), Room 1764, 50 Church street, New York, N. Y.

BISHOP, A. C., (1907), 321 Citizens Building, Cleveland, Ohio.

BLOCK, LOUIS, (1904), (Director 1905-'08, President 1909, Director 1911-'13), 45 East Forty-second street, New York, N. Y.

BORCHERS, HERBERT L., (1911), 2007 Baird avenue, Portsmouth, O.

BORGSTEDT, HENNING, N., (1905), 67 Park avenue, Yonkers, N. Y.

BOTCHFORD, H. J., (1905), Carbondale Machine Co., 1327 Candler Building, Atlanta, Ga.

*Bower, William H., (1911), Henry Bower Chemical Manufacturing Co., 2815 Gray's Ferry road, Philadelphia, Pa.

*Bowers, James, (1910), 106 West Eighteenth street, Wilmington, Del.

*Bracken, J. H., (1908), Union Insulating Co., 1614 Great Northern Building, Chicago, Ill.

Braungart, George, Jr., (1912), Southern Construction & Supply Co., 13 South Forsyth street, Atlanta, Ga.

*Bridgette, R. E., (1911), Bond and Douglas streets, Brooklyn, N. Y.

*Briggs, John N., (1907), Coeymans, N. Y.

Broas, Richard S., (1910), Starr Engineering Co., 90 West street, New York, N. Y.

Brostrom, Gustav R., (1909), 529 Linden avenue, York, Pa.

*Brownell, C. H., (1905), Washington Court House, Ohio.

*Burhorn, Edwin, (1905), 71 Wall street, New York, N. Y.

§Byrne, Frederick J., (1913), 623 Lexington avenue, New York, N. Y.

Carpender, Sydney B., (1913), Brunswick Refrigerating Co., New Brunswick, N. J.

Carpenter, Martin R., (1904), Triumph Ice Machine Co., Oakley, Cincinnati, O.

*Case, Charles L., (1904), (Director), Boston Terminal Refrigerating Co., 239 Sumner street, East Boston, Mass.

*Chamberlin, George E., (1912), Polar Wave Ice & Fuel Co., 1326 Chestnut street, St. Louis, Mo.

Chatard, William M., (1909). Chatard & Norris, 1415 Continental Building, Baltimore, Md.

Church, Fred B., (1904), Westinghouse, Church, Kerr & Co., 37 Wall street, New York, N. Y.

Cochran, Heywood, (1909), (Director), Carbondale Machine Co., 431 South Dearborn street, Chicago, Ill.

§Cole, Donald, (1907), General Ice Delivery Co., Detroit, Mich.

*Cole, Harold W., (1904), 9 Mountain terrace, Upper Montclair, N. J.

§Cole, Ralph N., (1913), Arctic Ice Machine Co., 920 South Market street, Canton, Ohio.

§Crawford, Gilbert H., Jr., (1913), De La Vergne Machine Co., 380 Bourse Building, Philadelphia, Pa.

*Criss, Charles L., (1906), Liberty and Second avenues, Pittsburgh, Pa.

Criswell, A. P., (1904), (Director), 419 Fisher Building, Chicago, Ill.

*Croll, Cecil H. G., (1905), Wellington Meat Export Co., Ngahruranga, Wellington, N. Z.

Daly, Benjamin F., (1905), Hollands, Rockaway Beach, N. Y.

*Dannenbaum, Hermann, (1912), National Ammonia Co., Frankford, Philadelphia, Pa.

*Dawley, C. W., (1912), 346½ East Choctaw avenue, McAlester, Okla.

§Day, Abram, (1910), 160 Williamson avenue, Bloomfield, N. J.

De Hart, John S., Jr., (1904), (Director), Isbell-Porter Co., 46 Bridge street, Newark, N. J.

De Kinder, J. J., (1904), (Director 1907-'09), The American Society of Refrigerating Engineers, 154 Nassau street, New York, N. Y.

§DELLE, FRANK A., (1907), Pilsbry-Becker Engineering & Supply Co., 200 North Main street, St. Louis, Mo.

DETTMAR, E., (1908), 1657 Monadnock Building, Chicago, Ill.

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INDEX TO VOLUME IX.

PAGE.

Amendments to Constitution 95
Ammonia Condensers, Recent Types of, and Their Efficiencies..... 68
Ammonia Purifiers or Regenerators and Foreign Gases in Refrigerating Systems—*Discussion* 259
BAARS, ERNST S. H., A Review ot the Feed Systems of Refrigerating Coils and Their Respective Advantages 216
Banquet, Ninth Annual Meeting 102
BRACKEN, J. H., Refrigerator Car—Retrospective and Prospective.... 137
Bureau of Standards, Report from 94
By-Laws and Constitution 7
Central Station, Electricity for Ice Making and Refrigeration as Supplied by the 173
Chemistry of Raw Water Can Ice—JOHN C. SPARKS..... 159
Cold Storage Legislation Committee, Report of..... 93
Committees, Personnel of 89
Committee on Standardization of Ammonia Fittings, Report of..... 23
Committee on Suggesting a Standard Basis for Finding the Fuel Economy of Steam Driven Ice Plants, Report of..... 23
Committee on Suggesting a Standard Tonnage Basis of Refrigeration and Standard Method of Testing Refrigerating Machinery, Report of 22
Committee on Temporary Physical Constants, Report of..... 23
Constitution, Amendments to 95
Constitution and By-Laws 7
Council, The, Report of 87
Deficit Fund Committee, Report of 93
Defining the Heat Conductivity of Insulators—CHARLES H. HERTER.... 230
Electricity for Ice Making and Refrigeration as Supplied by the Central Station—C. H. STEVENS.. 173
Feed Systems of Refrigerating Coils and Their Respective Advantages, A Review of 216
Fifth National Conservation Congress Committee, Report of..... 93
Finance Committee, Report of 87
Foreign Gases in Refrigerating Systems..... 259
Fruits—Their Handling and Storage—J. L. HUGHES..... 203
HERTER, CHARLES H., Defining the Heat Conductivity of Insulators.... 230
HUGHES, J. L., Fruits—Their Handling and Storage..... 203
Ice Making and Refrigeration, Electricity for, as Supplied by the Central Station 173
Ice, Raw Water 36
Ice, Raw Water Can, Chemistry of..... 159

PAGE.

Incorporation, Date of 2
Insulators, Defining the Heat Conductivity of 230
McPIKE, EUGENE F., Refrigerator Car—Retrospective and Prospective 125
Members and Guests Attending Ninth Annual Meeting..... 101
Members and Guests Attending Third Western Meeting..... 24
Members, List of 273
Members, New, 1913 88
Memoriam, In 271
NEFF, PETER, Presidential Address, Ninth Annual Meeting 107
NEFF, PETER, Presidential Address, Third Western Meeting 31
Ninth Annual Meeting, Proceedings of..... 85
Officers, 1913 3
Officers, 1914 97
Officers, Past and Present 4
Organization, Date of 2
Papers in Volume IX 27
Physical Constants Committee, Report of 23
Presidential Address, Ninth Annual Meeting—PETER NEFF 107
Presidential Address, Third Western Meeting—PETER NEFF 31
Proceedings of Ninth Annual Meeting 85
Proceedings of Third Western Meeting 21
Raw Water Ice—*Discussion*..... 36
Raw Water Can Ice, Chemistry of 159
Recent Types of Ammonia Condensers and Their Efficiency—*Discussion* 68
Refrigerating Coils, A Review of the Feed Systems of, and Their Respective Advantages 216
Refrigeration and Ice Making, Electricity for, as Supplied by the Central Station 173
Refrigerator Car—Retrospective and Prospective—J. H. BRACKEN.... 137
Refrigerator Car—Retrospective and Prospective—EUGENE F. MCPIKE 125
Resolutions Committee, Report of 98
Review of the Feed Systems of Refrigerating Coils and Their Respective advantages—ERNST S. H. BAARS 216
SPARKS, JOHN C., Chemistry of Raw Water Can Ice..... 159
Sterilization of Water by Ultra-Violet Rays—Max von Recklinghausen 112
STEVENS, C. H., Electricity for Ice Making and Refrigeration as Supplied by the Central Station 173
Tellers of Election of Members, Report of, Ninth Annual Meeting.... 85
Tellers of Election of Members, Report of, Third Western Meeting.... 22
Tellers of Election of Officers, Report of..... 96
Third Wstern Meeting, Proceedings of 21
TORRANCE, President-elect, Remarks of 97
Ultra-Violet Rays, Sterilization of Water by..... 112
VON RECKLINGHAUSEN, MAX, Sterilization of Water by Ultra-Violet Rays 112
Water, Sterilization of, by Ultra-Violet Rays..... 112

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